C007/0005
#3615

Canyon Fuel Company, LLC.
Skyline Mine
A Subsidiary of Arch Western Bituminous Group, LLC

COPY

Gregg Galecki, Environ. Engineer
HCR 35, Box 380
Helper, UT 84526
(435) 448-2636 - Office
(435) 448-2632 - Fax

September 16, 2010

Mr. Daron R. Haddock
Division of Oil, Gas, and Mining
1594 West North Temple
Salt Lake City, Utah 84114-5801

RE: North of Graben Incidental Boundary Change, Canyon Fuel Company, LLC, Skyline Mine, C/007/005,

Dear Daron:

Attached to this letter is pertinent information requesting an Incidental Boundary Change (IBC) to the Skyline Mine permit. The IBC adds approximately 320 acres to the area approved for underground mining activities located north of the Winter Quarter Canyon graben.

The modification is necessary to maximize coal recovery by rotating the proposed longwall panels from a north-south to east-west orientation. Representatives for Canyon Fuel Company are actively pursuing acquisition of a privately-held lease necessary for mining. Skyline Mine personnel understand final approval cannot be granted without Right-of-Entry information. It is our hope that the technical review can move forward in the meantime. Other information includes modifications to the following monitoring programs: groundwater, surface water, aquatic wildlife, vegetation, and subsidence. No surface disturbance is associated with this modification.

Attached to this cover letter are completed C1 and C2 forms, a guidance document provided for the technical reviewer to locate the relevant modifications, three (3) redline-strikeout copies of M&RP text modifications, numerous plates, an Earthfax Engineering report extending the 2004 GPS survey in Woods Canyon, and an Agapito Associates engineering report providing a numerical modeling report evaluating subsidence in Woods Canyon. Plates needing certification will be certified when clean copies are submitted at final approval.

If you have any questions regarding this information, please give me a call at (435) 448-2636.

Sincerely:

Gregg A. Galecki

Gregg A. Galecki
Canyon Fuel Company, LLC.
Environmental Engineer – Skyline Mines

Enclosures

File in:
☐ Confidential
☒ Shelf
☐ Expandable
Date Folder 09/16/10 C0070005

See: InComing For additional information

APPLICATION FOR COAL PERMIT PROCESSING

COPY

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: Canyon Fuel Company, LLC

Mine: Skyline Mine **Permit Number:** C/007/005

Title: Winter Quarters Access Road

Description, Include reason for application and timing required to implement:

Three (3) review copies of North of Graben - Incidental Boundary Change

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: ___ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☒ Yes ☐ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☒ Yes ☐ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☒ Yes ☐ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☒ Yes ☐ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☒ Yes ☐ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☒ Yes ☐ No 19. Does the application require or include certified designs, maps or calculation?
☒ Yes ☐ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☒ Yes ☐ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach three (3) copies of the application. (This number includes a copy for the Price Field Office.)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Wesley K Sorensen
Print Name

Wesley K Sorensen General Manager 9/16/10
Sign Name, Position, Date

Subscribed and sworn to before me this 16th day of Sept, 20 10

Kathleen Atwood
Notary Public

My commission Expires: 11-12, 2011

Attest: State of Utah } ss:
County of Carbon

KATHLEEN ATWOOD
NOTARY PUBLIC-STATE OF UTAH
100 NORTH 200 WEST #13
HUNTINGTON, UT 84528
COMM. EXP. 11-12-2011

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining

Form DOGM- C1 (Revised 3/22/2010)

APPLICATION FOR COAL PERMIT PROCESSING

Detailed Schedule Of Changes to the Mining And Reclamation Plan

COPY

Permittee: Canyon Fuel Company, LLC

Mine: Skyline Mine **Permit Number:** C/007/005

Title: North of Graben - Incidental Boundary Change (IBC)

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

Add	Replace	Remove	DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐	☒	☐	Section 1: pages 1-30, 1-32, 1-38, 1-39, 1-39a
☐	☒	☐	Section 2.3: pages2-35c, 2-36, 2-36a, 2-36b, 2-38, Figure 2.3.7-1 (page 2-38a)
☐	☒	☐	Section 2.4: pages 2-2-44a, 2-44b,
☐	☒	☐	Section 2.5: pages 2-51d, 2-51g
☐	☒	☐	Section 2.2: pages 2-61c, 2-61d
☐	☒	☐	Section 2.8 pages 2-67, 2-71a
☐	☒	☐	Section 4.17 pages 4-92, 4-93, 4-94, 4-95a, 4-95c
☐	☐	☒	Section 4.17: REMOVE plate 4.17.1-1 from text
☐	☒	☐	Plates 1.6-1, 1.6-3, 2.2.1-1, 2.2.7-7, 2.3.4-2, 2.3.6-1, 2.3.6-2, 2.8.1-1, 3.1.8-2, 3.3-2, 4.17.1-1, 4.17.3-1A,
☒	☐	☐	Appendix Volume A-1, Volume 2; Addition to 2004 Woods Canyon GPS survey, Earthfax Engineering, Inc. 2010 (ADD TEXT TO 2004 REPORT)
☐	☒	☐	Appendix Volume A-1, Volume 2: 2004 Woods Canyon GPS survey, Earthfax Engineering June 29, 2004, REPLACE Plates 1 and 2
☒	☐	☐	Appendix Volume A-1, Volume 2; Woods Canyon Subsidence Study, Skyline Mine; Agapito Associates, Inc. June 2010
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☐	☐	☐	

Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	**Received by Oil, Gas & Mining**
Three (3) redline copies to the Salt Lake Office.	

COPY

Guidance Document
North of Graben
Incidental Boundary Change (IBC)

The following is intended to guide the technical reviewer through the attached information concerning modifying the boundary permitted for underground mining activities to include an additional 320 acres. The Incidental Boundary Change (IBC) was necessary to accommodate a rotation of the longwall panels from north-south to east-west, north of Winter Quarters Canyon graben. Due to the panel orientation modification, mining will be extended approximately ½ mile east of the area currently permitted for mining.

Section 1
Right-of- Entry; changing the panel orientation to the east-west extends mining further east. The extension requires Skyline acquiring the right-of-entry into the Hanson Resources land located in Section 36, T12S, R6E, which Arc Land is currently acquiring. We are hoping we can work through the permitting process with the understanding that final approval will not be granted without right-of-entry information (page 1-32, Hanson information added to Appendix 118-A)

Description of Permit Area: DOGM staff has requested that the legal description be modified to be more precise and described down to the ¼ , ¼ section (page 1-38, Plates 1.6-1 and 1.6-3).

Description of Adjacent Area: The description of the Adjacent area was modified after discussions with the DOGM staff. The area has been modified to include lease areas (areas approved for underground mining activities), and the areas permitted for surface disturbance activities (page 1-39, 1-39a, Plates 1.6-1 and 1.6-3).

Section 2
Section 2.3 – Groundwater Hydrology; water monitoring in Woods Canyon has been increased to include surface monitoring site CS-25, and five (5) piezometers (WC-1 through WC-9) and Spring 36-1. The water monitoring site additions were necessary as mining extended further east than originally planned (pages 2-35c, Table 2.3.7-1 which includes pages 2-36, 2-36a, 2-38, and Figure 2.3.7-1 on page 2-38a, Plate 2.3.4-2, 2.3.6-1, 2.3.6-2).

Section 2.4 – Surface-water Hydrology; extending mining to the east in Woods Canyon required the addition of surface water monitoring site CS-25 and shallow groundwater piezometers WC-1 through WC-9 (pages 2-44a, 2-44b).

Section 2.5 – Hydrologic Impacts of Mining Activites: modifying the panel orientation to include additional acreage to the east, lessens the amount of overburden on the eastern portions of the panels – specifically, in Woods Canyon

Creek. Agapito Associates has conducted a study indicating longwall mining can be conducted in areas with 475 feet of overburden based on the geology in the area (pages 2-51d, 2-51g).

Section 2.7 – Vegetation: affects of mining on vegetation are already addressed in a survey that was initiated in 2002 and continues today. Baseline sampling in Woods Canyon will be extended to include the additional mining (pages 2-61c, 2-61d)

Section 2.8 – Aquatic Wildlife Resources: additional monitoring sites will be added to both macroinvertebrate and fish studies in Woods Canyon Creek (pages 2-67, 2-71a, Plate 2.8.1-1)

Section 4.17 – Subsidence Control Plan: potential subsidence in Woods Canyon has been considered with an addition to the 2004 GPS gradient survey of the creek, installation of piezometers along the creek, and a numeric modeling study of the anticipated subsidence. Discussions of the Subsidence study are outlined in Appendix A-1, Volume 2 (pages 4-92, 4-93, 4-94, 4-95a, 4-95c, Plates 4.17.1-1, 4.17.3-1A, Addition to GPS survey – Appendix A-1, Volume2, Agapito Subsidence study – Appendix A-1, Volume 2)

Section 1: pages 1-30, 1-32, 1-38, 1-39, 1-39a

114 Right-of-Entry Information

The Skyline Mines will be operated on the leasehold interests owned by Canyon Fuel Company, LLC. The lands on which mining is to occurs includes part of the Manti-LaSal National Forest, and both county and private leases (see Drawings 1.6-1 and 1.6-3 of the unmodified permit). Post mining land use of National Forest lands are outlined in the approved Manti-La Sal Forest Land Use Management Plan. The waste rock disposal area and Winter Quarters Ventilation Facility are on private land as also shown on Drawing 1.6-1. The leasehold interests involve all or a part of the following coal leases, which have been subleased and/or assigned to Canyon Fuel Company, LLC (additional information provided on Table 114.1):

Federal Lease	Issued to	Date of Issuance
Utah - 020305	Emmett K. Olson	03/01/62
Utah - 044076	Armeda N. McKinnon	09/01/65
Utah - 0142235	Malcolm N. McKinnon	10/01/64
Utah - 0147570	Malcolm N. McKinnon	05/01/65
Utah - 073120	Independent Coal and Coke Company	02/01/64
Utah - 67939	Coastal States Energy Co.	09/01/96

County Lease	Issued to	Date of Issuance
Carbon County Coal Lease	Kanawha and Hocking Coal and Coke Company	5/1/74
Carbon County Coal Lease	Canyon Fuel Company, LLC	05/15/02

Private Lease	Issued to	Date of Issuance
UP&L Tract	Canyon Fuel Company, LLC	2/1/99
C&B Energy	Canyon Fuel Company, LLC	8/1/02
Hanson Natural Resources	Ark Land Company	??/??/10

The legal descriptions of the above listed coal leases are:

Federal Coal Lease Serial #Utah-020305

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 13:	SW-1/4 SW-1/4 (Lot 7);
Sec. 14:	SE-1/4 SE-1/4;
Sec. 23:	E-1/2 E-1/2;
Sec. 24:	W-1/2 NW-1/4, SE-1/4 NW-1/4, S-1/2;

Section 24: NE-1/4 NW-1/4;
containing 557.22 acres

Federal Coal Lease Serial # UTU - 67939

T.12 S., R.6.E., SL Meridian, Utah
Section 26, S2SE, SESW
Section 34, Lots 1-4, S2NE, SENW, E2 SWNW, N2S2
Section 35, all

T.13S., R.6E., SL Meridian, Utah
Section 2, all
Section 3, all
Section 10, Lots 1-2, NE, E2NW;
Section 11, N2, N2S2
containing 3,291.0 Acres

Carbon County Coal Lease

Township 12 South. Range 6 East SLB&M
Section 36: S1/2S1/2
containing 160.0 Acres

Township 13 South. Range 6 East SLB&M
Section 1: W1/2
Section 12: NW1/4NW1/4, SW¼SW¼
Section 24: Portion of W1/2 NE1/4
containing 465 Acres more or less

Pacificorp Coal Lease

Township 14 South, Range 6 East, SLB&M
Section 2: Lots 1, 2, 3, and 4; S1/2N1/2;S1/2 (All)
Section 3: Lots 1 and 2; S1/2NE1/4; E1/2SE1/4; E1/2W1/2SE1/4;
NW1/4NW1/4SE1/4
containing 925.16 acres more or less

C&B Energy

Township 13 South. Range 6 East SLB&M
Section 1: W1/2SE1/4;
Section 12: NW1/4SW1/4, SW1/4NW1/4, NE1/4NW1/4
containing 200 acres more or less

Hanson Natural Resources

Township 12 South, Range 6 East SLB&M
Section 36: N1/2SW1/4, S1/2NW1/4

Legal Description of Permit Area

Township 12 South, Range 7 East, SLBM

Section 32: Portion SE1/4SE1/4

Township 13 South, Range 6 East, SLBM

Section 1: Portions of S1/2NW1/4, S1/2NE1/4
Section 13: Portions of S1/2S1/2
Section 23: Portions of SE1/4NE1/4
Section 24: Portions of NE1/4SW1/4
Section 25: Portions of S1/2S1/2
Section 35: Portions of NE1/4, S1/2
Section 36: Portions of N1/2NW1/4

Township 13 South, Range 7 East, SLBM

Section 4: Portions of SW1/4NW1/4, NW1/4SW1/4
Section 5: Portions of E1/2NW1/4
Section 6: Portions of S1/2S1/2
Section 17: Portions of S1/2S1/2
Section 18: Portions of S1/2S1/2
Section 19: Portions of N1/2N1/2

Township 14 South, Range 6 East, SLBM

Section 2: Portions of W1/2NW1/4
Section 3: Portions of SE1/4NE1/4

See Plate 1.6-3 for graphic illustration of Permit Area

Legal Description of Areas Approved for Underground Coal Mining and Reclamation Activites~~Adjacent Area~~

Township 12 South, Range 6 East, SLBM

~~Section 25:~~	~~Portion~~
Section 26:	S1/2SE1/4, SE1/4SW1/4~~Portion~~
~~Section 27:~~	~~Portion~~
~~Section 33:~~	~~Portion~~
Section 34:	Portions of S1/2N1/2, S1/2~~All~~
Section 35:	All
Section 36:	All

Township 12 South, Range 7 East, SLBM

~~Section 30:~~	~~Portion~~
~~Section 31:~~	~~Portion~~
Section 32:	Portions of SE1/4SE1/4
~~Section 33:~~	~~Portion~~

Township 13 South, Range 6 East, SLBM

Section 1:	Portions of S1/2NE1/4, portions of SE1/4NW1/4~~All~~
Section 2:	All
Section 3:	All
~~Section 4:~~	~~Portion~~
~~Section 9:~~	~~Portion~~
Section 10:	All
Section 11:	All
Section 12:	W1/2SW1/4, W1/2NW1/4, NE1/4NW1/4~~Portion~~
Section 13:	W1/2, portions S1/2SW1/4~~All~~
Section 14:	All
Section 15:	All
~~Section 16:~~	~~Portion~~
~~Section 21:~~	~~Portion~~
Section 22:	All
Section 23:	All
Section 24:	W1/2, ~~P~~portions of W1/4E1/2
Section 25:	Portions of W1/2
Section 26:	All
Section 27:	All
~~Section 28:~~	~~Portion~~
~~Section 33:~~	~~Portion~~
Section 34:	All
Section 35:	W1/2, portions of E1/2~~All~~
~~Section 36:~~	~~Portion~~

Township 13 South, Range 7 East, SLBM

Section 4:	Portions of NW1/4SW1/4, portions of SW1/4NW1/4
Section 5:	Portions of E1/2NE1/4
Section 6:	Portions of S1/2N1/2
~~Section 7:~~	~~Portion~~
~~Section 8:~~	~~Portion~~
~~Section 9:~~	~~Portion~~
~~Section 16:~~	~~Portion~~
Section 17:	Portions of S1/2S1/2
Section 18:	Portions of S1/2S1/2
Section 19:	Portions of N1/2NW1/4
~~Section 20:~~	~~Portion~~
~~Section 21:~~	~~Portion~~

Legal Description of Areas Approved for Underground Coal Mining and Reclamation Activities~~Adjacent Area~~

Township 12 South, Range 6 East, SLBM

Section 25: ~~Portion~~ SE1/4NE1/4, E1/2SE1/4
Section 26: S1/2SE1/4, SE1/4SW1/4~~Portion~~
~~Section 27: Portion~~
~~Section 33: Portion~~
Section 34: Portions of S1/2N1/2, S1/2~~All~~
Section 35: All
Section 36: W1/2~~All~~

Township 12 South, Range 7 East, SLBM

~~Section 30: Portion~~
~~Section 31: Portion~~
Section 32: Portions of SE1/4, portions of E1/2SW1/4
~~Section 33: Portions~~ of SW1/4, portions of SW1/4SE1/4

Township 13 South, Range 6 East, SLBM

Section 1: Portions of S1/2NE1/4, W1/2, W1/2SE1/4~~All~~
Section 2: All
Section 3: All
~~Section 4: Portion~~
~~Section 9: Portion~~
Section 10: All
Section 11: All
Section 12: W1/2SW1/4, W1/2NW1/4, NE1/4NW1/4~~Portion~~
Section 13: W1/2, portions S1/2SE1/4~~All~~
Section 14: All
Section 15: All
~~Section 16: Portion~~
~~Section 21: Portion~~
Section 22: All
Section 23: All
Section 24: W1/2, ~~P~~portions of NE1/4
Section 25: Portions of W1/2
Section 26: All
Section 27: All
~~Section 28: Portion~~
~~Section 33: Portion~~
Section 34: All
Section 35: All
Section 36: Portions of N1/2NW1/4

Township 13 South, Range 7 East, SLBM

Section 4: Portions of W1/2, portions of W1/2E1/2
Section 5: Portions of E1/2, portions of NE1/2NW1/4
Section 6: Portions of S1/2N1/2
~~Section 7: Portion~~
~~Section 8: Portion~~
~~Section 9: Portion~~
~~Section 16: Portion~~
Section 17: Portions of S1/2S1/2
Section 18: Portions of S1/2S1/2
Section 19: Portions of N1/2NW1/4
~~Section 20: Portion~~
~~Section 21: Portion~~

Township 14 South, Range 6 East, SLBM

~~Section 1: Portion~~
Section 2: All-
Section 3: All
~~Section 4: Portion~~
~~Section 9: Portion~~
~~Section 10: Portion~~
~~Section 11: Portion~~
~~Section 12: Portion~~

Total acres approved for Underground Coal Mining and Reclamation activities: ~~within the ADJACENT AREA~~: 13,525~~20,836~~

The acreage of 13,525~~20,836~~ acres is an AutoCad ® generated number from drawing number 1.6-3 .

72-38

Section 2.3: Pages 2-35c, 2-36, 2-36a, 2-36b, Figure 2.3.7(Pg. 2-3-8a)

should be accessible for the next several years. The results of the analyses will be monitored for changes in ages that may indicate changes in the source of the mine water inflows. These samples will be obtained as outlined in Table 2.3.7-1.

Samples of water discharging from springs 8-253 (Flat Canyon area), 2-413 (James Canyon), S24-1 (Sulfur Spring in Huntington Canyon), and S15-3 (Upper Huntington Creek) will be collected during the 2nd Quarter(April - June) and 4th Quarter(October - December) monitoring period and analyzed for tritium content. Additional tritium samples will be obtained from EL-1 (inflow to Electric Lake above JC-1 and JC-3 discharge) and EL-2 (outflow from Electric Lake) during the 2nd, 3rd, and 4th Quarter water monitoring periods. These samples will be collected for a period of three years beginning in the spring of 2004. The purpose of collecting these tritium samples, along with the tritium samples from JC-1, is to monitor the change in tritium content, if any, in the local aquifers and Electric Lake during spring, summer, and fall and over the three year period.

Surface-water will be monitored in the vicinity of the Winter Quarters Ventilation Facility (WQFV) by two (2) stream sites located both up- and downstream of the site, CS-20 and CS-24, respectively. The stream sites will monitor the surface- water ensuring neither the shaft or slope is compromising the surface water system. Groundwater Well 08-1-5 is screened from 297-317 feet below the surface and will monitor the water elevation below the coal seam. No springs exist on the south facing slope where the WQVF pad is located. Spring WQ1-1 is located on the north-facing slope, is approximately 1/4-mile east of the WQVF pad and monitors near surface groundwater south and east of the WQVF site.

Both surface-water and groundwater monitoring sites were added in Woods Canyon as mining was extended to the east in Section 36, T12S, R6E. CS-25 will monitor stream flow downstream of all mining activity. Shallow ground water along Woods Canyon Creek will be monitored by piezometers WC-1, WC-3, WC-5, WC-7, and WC-9. Spring WQ36-1 will monitor groundwater within the Blackhawk formation above active mining areas.

Table 2.3.7-1
Comprehensive Water Quality Analytical Schedule
(Surface and Ground Water Stations)

	1st Quarter						2nd[2] / 3rd[3] / 4th Quarters												
Sample Site	Lab Analysis*[a]	Field parameters only*[1]	Monthly Flow	Dissolved Oxygen	TDS,TSS, T-P	O & G	Lab Analysis*[a]	Qtrly Field parameters* only[1]	Quarterly Flow	Monthly Flow	Monthly Seasonal Flow	Quarterly Water Level Only	Dissolved Oxygen	TDS,TSS, T-P	O & G	Carbon 14	Tritium	Deuterium	Oxygen 18
Streams																			
CS-3							X								X				
CS-6**	X			X			X						X						
CS-7 (F-5)								X											
CS-8								X											
CS-9							X												
CS-10								X											
CS-11							X								X				
CS-12	X						X												
CS-13	X						X												
CS-14	X						X												
CS-16								X											
CS-17								X											
CS-18								X											
CS-19							X												
CS-20							X												
CS-21							X												
CS-22									X										
CS-23									X										
CS-24							X								X				
CS-25							X												
MD-1			X		X					X				X					
SRD-1			X							X									
F-10											X								
UP&L-10							X												
VC-6	X			X		X	X						X		X				
VC-9	X			X		X	X						X		X				
VC-10		X						X											
VC-11									X										
VC-12									X										
NL-1 through NL-42 (See Section 2.4.4)											X								

Revised 9-16-10

Table 2.3.7-1
Comprehensive Water Quality Analytical Schedule
(Surface and Ground Water Stations)
(continued)

	1st Quarter							2nd[2] / 3rd[3] / 4th Quarters												
Sample Site	Lab Analysis*[a]	Field parameters only*[1]	Monthly Flow	Dissolved Oxygen	TDS,TSS, T-P	O & G		Lab Analysis*[a]	Qtrly Field parameters* only[1]	Quarterly Flow	Monthly Flow	Monthly Seasonal Flow	Quarterly Water Level Only	Dissolved Oxygen	TDS,TSS, T-P	O & G	Carbon 14	Tritium	Deuterium	Oxygen 18
Streams (cont.)																				
WRDS #1								X								X				
WRDS #2								X								X				
WRDS #3								X								X				
WRDS #4								X								X				
EL-1																		X		
EL-2																		X		
Springs																				
S10-1								X												
S12-1								X												
S13-2									X											
S13-7								X												
S14-4									X											
S15-3									X									X		
S17-2								X												
S22-5									X											
S22-11									X											
S23-4									X											
S24-1 Sulfur Spring									X									X		
S24-12									X											
S26-13									X											
S34-12									X											
S35-8									X											
S36-12									X											
2-413									X									X		
3-290									X											
8-253																		X		
WQ1-1									X											
WQ1-39								X												
WQ3-6								X												
WQ3-26								X												
WQ3-41								X												
WQ3-43								X												
WQ4-12								X												
WQ36-1								X												

Revised 9-16-10

Table 2.3.7-1
Comprehensive Water Quality Analytical Schedule
(Surface and Ground Water Stations)
(continued)

Sample Site	1st Quarter: Lab Analysis*[a]	1st Quarter: Field parameters only*[1]	1st Quarter: Monthly Flow	1st Quarter: Dissolved Oxygen	1st Quarter: TDS,TSS, T-P	1st Quarter: O & G		2nd[2] / 3rd[3] / 4th Quarters: Lab Analysis*[a]	2nd[2] / 3rd[3] / 4th Quarters: Qtrly Field parameters* only[1]	2nd[2] / 3rd[3] / 4th Quarters: Quarterly Flow	2nd[2] / 3rd[3] / 4th Quarters: Monthly Flow	2nd[2] / 3rd[3] / 4th Quarters: Monthly Seasonal Flow	2nd[2] / 3rd[3] / 4th Quarters: Quarterly Water Level Only	2nd[2] / 3rd[3] / 4th Quarters: Dissolved Oxygen	2nd[2] / 3rd[3] / 4th Quarters: TDS,TSS, T-P	2nd[2] / 3rd[3] / 4th Quarters: O & G	2nd[2] / 3rd[3] / 4th Quarters: Carbon 14	2nd[2] / 3rd[3] / 4th Quarters: Tritium	2nd[2] / 3rd[3] / 4th Quarters: Deuterium	2nd[2] / 3rd[3] / 4th Quarters: Oxygen 18
Wells																				
JC-1			X						X		X				X		X	X	X	X
JC-3			X						X		X				X					
ELD-1			X								X									
W79-10-1B													X							
WC-1, WC-3, WC-5, WC-7, WC-9													X							
W79-14-2A													X							
W79-26-1													X							
W79-35-1A													X							
W79-35-1B													X							
W2-1(98-2-1)													X							
W20-4-1													X							
W20-4-2													X							
W99-4-1													X							
W99-21-1													X							
W20-28-1													X							
91-26-1													X							
91-35-1													X							
92-91-03								X												
08-1-5													X							

* Field Measurements and Laborotory Analyses are defined in Table 2.3.7-2

[a]Field parameters will be taken in conjunction with samples collected for Lab Analyses

[1]Sites with at least two (2) years of laboratory analysis data will be sampled once every five (5) years for the currently approved laboratory parameters in Table 2.3.7-2 beginning in 2010. If field parameter monitoring indicates any trending changes, regular laboratory analysis may be resumed until trend is adequately characterized.

[2]2nd Quarter sampling may extend to July 15 in years when spring snow conditions do not allow access before June.

[3] Baseline Lab Analysis will be conducted every five (5) years beginning in 2010 in the 3rd quarter. (ie. Years 2010, 2015, 2020, etc.)

** Flow measurements discontinued at CS-6 in 12/2009, lower Eccles flow documented with VC-9

Revised 9-16-10

TABLE 2.3.7-3
MONITORING STATION IDENTIFICATION

ECCLES CANYON/MUD CREEK DRAINAGES

STREAM STATIONS - 14~~13~~ Stations

CS-3	CS-6	CS-9	CS-11	CS-19	CS-20	CS-24
CS-21	VC-6	VC-9	VC-10	VC-11	VC-12	CS-25
NL sites (varies)		–				

MINE DISCHARGE STATIONS - 4 Stations
CS-12 (Mine #3) CS-14 (Mine #1) MD-1 (Composite CS-12 & CS-14)
SRD-1 (Total Mine Site Discharge to Eccles Creek/Scofield Reservoir)*

FRENCH DRAIN STATIONS - 1 Station
CS-13

HUNTINGTON CANYON

STREAM STATIONS - 12 Stations

CS-7 (F-5)	CS-8	CS-10	CS-16	CS-17	CS-18
CS-22	CS-23	UPL-10	F-10	EL-1	EL-2

WASTE ROCK DISPOSAL SITE

STREAM STATIONS - 4 Stations
WRDS #1 WRDS #2 WRDS #3 WRDS #4

GROUNDWATER STATIONS

SPRINGS - 27~~26~~ Stations

S10-1	S12-1	S13-2	S13-7	S14-4	S15-3	S17-2
S22-5	S22-11	S23-4	S24-1 Sulfur	S24-12	S26-13	S34-12
S35-8	S36-12	2-413	3-290	WQ1-39	WQ3-6	WQ3-26
WQ3-41	WQ3-43	WQ4-12	8-253	WQ1-1	WQ36-1	

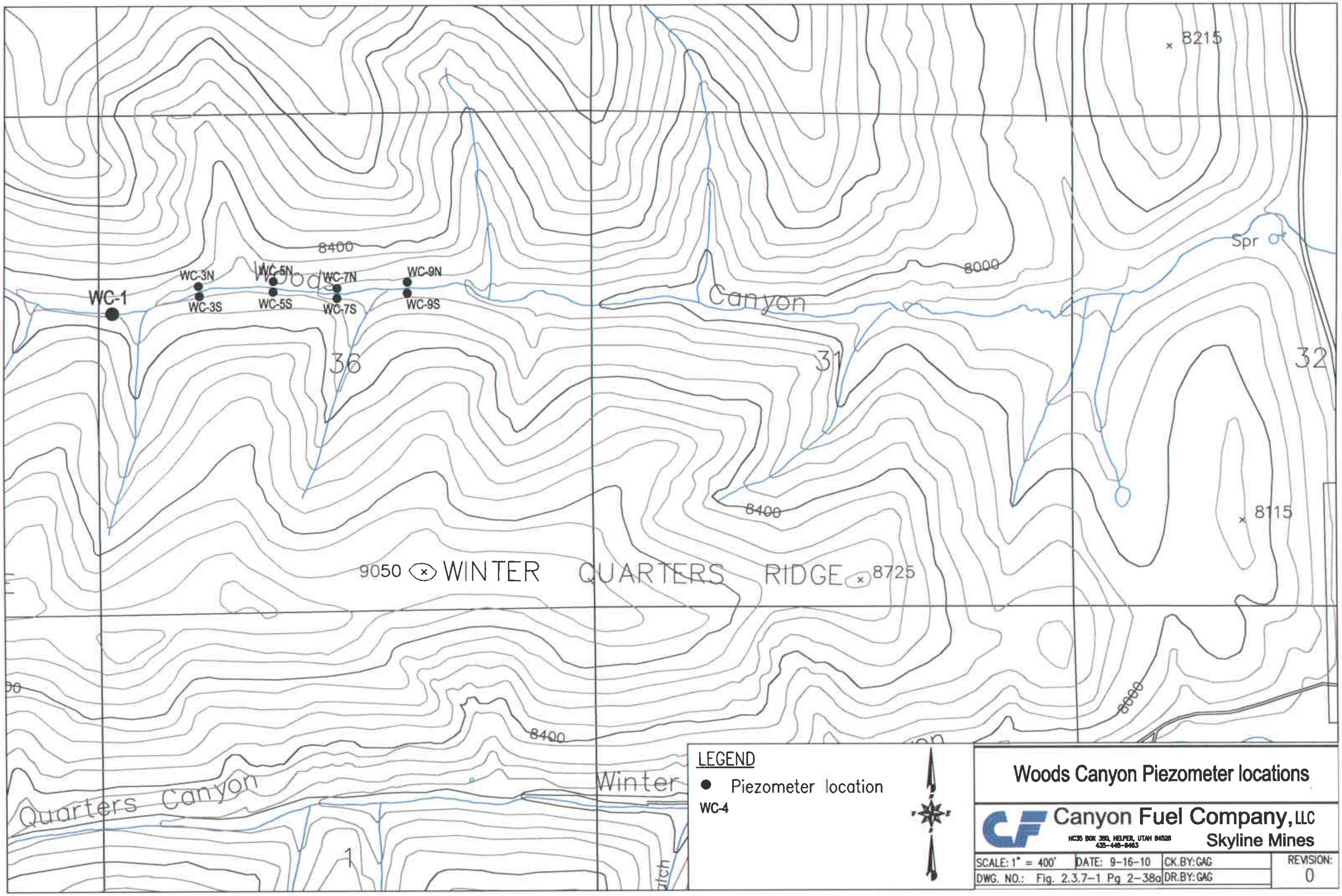
WELLS (MONITORING) - 1 Well Stations

W79-10-1B	W79-14-2A	W79-26-1	W79-35-1A	W79-35-1B
92-91-03	W2-1(98-2-1)	W20-4-1	W20-4-2	W99-4-1
W99-21-1	W20- 28-1	JC-1	JC-3	91-26-1
91-35-1	ELD-1 (Total of JC-1 and JC-3)*	W08-1-5	WC-1 thru WC-9	

WELLS, CULINARY -Referenced but not monitored
W13-1 W13-2 W17-1 W17-3 W24-1

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES)
001 Portal Area 002 Loadout Area 003 Waste Rock Area 004 Winter Quarters JC-3 James Canyon

* Sites are monitored for total flow only and the results are reported to the Division on a monthly basis.



LEGEND

● Piezometer location

WC-4

Woods Canyon Piezometer locations

Canyon Fuel Company, LLC

HC35 BOX 380, HELPER, UTAH 84526
435-448-6463

Skyline Mines

SCALE: 1" = 400'	DATE: 9-16-10	CK.BY: GAG	REVISION:
DWG. NO.: Fig. 2.3.7-1 Pg 2-38a		DR.BY: GAG	0

Section 2.4: 2-44a, 2-44b

Surface water stations in Eccles Canyon were sampled more frequently than those on Huntington Creek during the initial phases of mining.

Eccles Canyon stream stations are shown on Table 2.3.7-3 and are analyzed for those constituents identified in Tables 2.3.7-2 with an annual monitoring as per Table 2.3.7-1.

Stream monitoring station CS-24 was added in Winter Quarters Canyon, with the addition of sediment pond discharge point UPDES-004 from the Winter Quarters Ventilation Facility. Stream site CS-24 is located downstream of the Ventilation Facility pad, and UPDES-004 represents the discharge from the pad site. Sampling frequency and analysis are located in Tables 2.3.7-1, and 2.3.7-2, respectively.

Stream monitoring station CS-25 was added in Woods Canyon as mining progressed east in Section 36, T12S, R6E. CS- 25 is located downstream of any mining activity. In addition, nine (9) piezometers (WC-1 through WC-9N) were added in the canyon to monitor the near surface groundwater associated with Woods Canyon Creek.

Sampling will continue at all surface water stations throughout the post-mining period and until the reclamation effort is determined successful by the regulatory authority. Samples will also continue to be analyzed for the parameters outlined in Tables 2.3.7-1, 2.3.7-2, and 2.3.7-3 throughout the post-mining period, unless deletions in the list of parameters is determined to be appropriate.

Several monitoring stations were added to the monitoring schedule with the incorporation of the North Lease Tract. CS-19 and CS-21 have been added to monitor the quantity and quality of the water in Woods Canyon Creek and CS-20 has been added to monitor the quantity and quality of the water in Winter Quarters Creek - monitoring both mining upstream and water quality upstream of the Winter Quarters Ventilation Facility (WQVF). CS-24 was added in Winter Quarters Creek below the (WQVF) to monitor any affects associated with the pad.

As part of the Skyline Mine subsidence monitoring plan, a total of 42 new water monitoring sites have been identified in the North Lease area (Plate 2.3.6-2 Table 2.3.7-2A). Sites NL-1 through NL-42 have been selected to monitor flows on the perennial reaches of both Winter Quarters and Woods Canyon drainages one year prior to , during, and one year following longwall undermining of the perennial section of stream . The sites will be monitored monthly in June through October. If accessible earlier than June or later than October, the mine will monitor the sites. The results of the monitoring will be reported with the other required monitoring data. The purpose of this monitoring is to determine the effects, if any, on the stretches of perennial streams in the Winter Quarters Creek and Woods Canyon Creek drainage that will be subsided due to mining. Monitoring points, in perennial reaches running perpendicular to the longwall panels, are positioned above the gate-roads and center of each panel. Longwall panels are approximately 850-feet wide, creating a flow-monitoring spacing of approximately 425-feet. Monitoring points in perennial reaches running parallel to the longwall panels are spaced at approximately 850-feet. Since monitoring is dependent on the timing of mining, monitoring points will be added and dropped as mining advances. As mining advances through the perennial sections of the drainage, and the monitoring indicates no affects to flow, the Permittee may modify the spacing of the monitoring points. This monitoring will also help indicate if mitigation is required for loss of surface or ground water and, subsequently, habitat associated with the water.

Skyline has conducted field studies to determine the location of the perennial portions of both Winter Quarters and Woods Canyon Creeks~~, though no mining is currently planned within the next five years in the Woods Canyon drainage~~. The perennial nature of the streams were determined using a variety of parameters including vegetation and surface flow monitoring. Field studies were initiated and completed in October and November 2002 and October 2003. Copies of the studies are included in Appendix~~Volume~~ A-1, Volume 2 Hydrology Section. The studies will be used by the Forest in their environmental assessment of the potential effects of undermining Winter Quarters and Wood Canyon Creeks. As mining progressed north of Winter Quarters Canyon, the longwall panels were rotated 90 degrees which extended mining further east. Agapito Associates, Inc. conducted an evaluation of the impacts to the surface based on extending mining to the east. The study indicated longwall mining can be safely extended to the east as outlined without having adverse affects to the surface. The study is located in Appendix A-1, Volume 2.
Sampling will continue according to Tables 2.3.7-1, 2.3.7-2, and 2.3.7-3 as approved at all surface water stations throughout the post-mining period and until the reclamation effort is determined successful by the

Section 2.5: pages 2-51d, 2-51g

The water consumed in operating underground equipment, dust suppression, and evaporation is obtained from ground water sources within the mine. These underground water sources are not connected to the surface waters in the area. Extensive research has been performed by the mine to verify that water currently entering the mine is not coming from the surface or depleting surface waters. The recent July 2002 Addendum to the PHC presents data supporting this statement. The data suggests the water intercepted underground is at least 4,000 to 25,000 years old and, based on the results of tritium analyses from most of the mine waters, does not typically contain water that has been exposed to the atmosphere in the past 50 years. Additionally, the steady rate of decline in ground water levels in monitoring wells within the permit area and the results of age-dating the ground water inflows to the mine indicating the water is not getting appreciably younger, suggests that the aquifer is not receiving significant recharge of "young" surface waters.. Continued monitoring by the mine of the surface waters and seeps and springs flows in the permit and adjacent areas have shown no discernable impacts due to the increased mine inflows that were encountered in March 1999 and have continued through November 2002. It is the operator's position that the water consumed in operating Skyline Mine is not depleting surface water sources. In fact, there is an overall net gain to local river systems discharging to the Colorado River as a result of Skyline Mine discharge.

In anticipation of the Winter Quarters Ventilation Facility being constructed, a discharge point (004) was added to accommodate both storm water and mine discharge into Winter Quarters Creek in 2009. A numeric model study conducted by Earthfax Engineering (Appendix A-1, Volume 2) indicates Winter Quarters Creek can receive a maximum discharge of 6,200 gpm while not being erosive to the creek. In the event discharge from Outfall 004 routinely exceeds 6,200 gpm additional armoring to the outfall location and investigation of the impacts to Winter Quarters creek will be initiated.

As mining progressed north of Winter Quarters Canyon, the longwall panel orientation was rotated 90 degrees to maximize the coal recovery. This rotation increased mining in an easterly direction into an area of thinner overburden. A study conducted by Agapito Associates indicates longwall mining can be conducted in areas with overburden down to 475 feet. In Panel 11 Left Woods Canyon creek overlies the center of the panel with overburden ranging from approximately 1000 feet to 500 feet. Water monitoring of the creek, shallow groundwater in the creek bottom, macroinvertebrate, fish and vegetation monitoring of the stream corridor will all be studied to monitor any impacts to the creek. Detailed discussions of water monitoring are discussed in Sections 2.3 and 2.4, with subsidence control plan discussed in Section 4.17 of this M&RP.

The following information is supplied as required by the Windy Gap process as it applies to existing coal mines in the Upper Colorado River basin:

Mine Consumption: (culinary well - Water Right 91-5010) =41.69 ac-ft (2004 consumption)

Ventilation Consumption / Evaporation:

(assumes 70 deg. F, 60 total days annually, 20% humidity air intake, 95% humidity air out-take; air density difference of 0.001 lbs/ft)

(353,312 cu-ft/min) (.001)(0.1198) = 42 gal/min.
= 11.21 ac-ft annually

Coal Producing Consumption / Coal Moisture Loss:

- 6.1% Inherent moisture
- 8.54 % run-of-mine moisture
- 2.44% moisture added to coal by cutting (8.54-6.1)

Projected 2005 Tonnage 237, 500 tons
Projected 5 yr Average 1,898,672 tons

Tons water/year = (1,898,672)(0.0244)= 46,328 tons water/year
Lbs water/year = 92,656,000
Gallons/year = 92,565,000 (0.1198)=11,100,189 gallons/year
=34.06 ac-ft annually

Sediment Pond Evaporation:

Evaporation estimate calculation uses evaporation data from Pacificorp evaporation pan located at Electric Lake spillway. Data was from 1998 through 2003.

Pond 001 (Mine Site) - 0.39 acre (surface area)

Very little ground water was encountered while mining in the northern portion of the existing permit area prior to the addition of the North Lease. . –The same geologic and hydrogeologic conditions are anticipated to occur in the North Lease as occurred in the northern portion of the existing permit area (Mine 3). From 2005 through 2009 no significant water has been encountered in the North Lease. Selected surface discharges of ground water and stream flows in the areas that could be impacted by mining activities have been monitored. Mining related surface impacts include subsidence and the ventilation facility in Winter Quarters Canyon (WQVF)in the North Lease area. The WQVF will be permitted to encompass approximately 7.93 acres with the disturbance being treated with a sedimentation pond. The sole purpose of the facility will be to provide ventilation to the mine. If impacts to the waters within the permit area are determined to have occurred, mitigation will be implemented immediately using BTCA as described previously.

North of Winter Quarters Canyon, north of the Winter Quarters graben (NOG), the longwall panels were rotated 90 degrees to maximize coal recovery. This rotation accommodates coal recovery approximately ½- mile further to the east. A study conducted by Agapito Associates indicates mining can be safely conducted in areas with as little as 475 feet overburden without seeing adverse affects related to subsidence.

There has been some concern that Electric Lake has been impacted by the inflows of ground water to the Skyline Mine since 1998. As presented in the Addendum to the Probable Hydrologic Consequences, July 2002 and updated in October 2002, April 2003, and June 2004, a direct connection between the water in Electric Lake and the mine inflows cannot be found. However, the water flowing into the 10 Left area of the mine and discharging from the James Canyon JC-1 well contains a slight percentage of tritium. No other significant inflows of ground water into the mine contained tritium levels that would suggest a modern component of recharge. As stated by Petersen (Appendix A, Addendum to the Probable Hydrologic Consequences, July 2002, Updated October 2002):

> "It is calculated that the maximum modern component in the fault-related system could range from approximately 6.9 to 12.4 percent. It is also apparent that since routine sampling of the 10 Left groundwater system began in May 2002, the percentage of modern recharge in the groundwater system has not increased. Based on the potential modern recharge percentage calculations presented above, it is determined that of the total inflow to the 10 Left region
> (approximately 3,800 gpm), a maximum of approximately 262 to 471 gpm could have originated as modern recharge. Inasmuch as Canyon Fuel has been pumping approximately 2,200 gpm from the 10 Left groundwater system into Electric Lake since September 2001, the potential net impact to the Electric Lake watershed, were it occurring, would be completely mitigated by the current pumping. Additionally, groundwater that would not otherwise be available for use without the pumping activity is being added to the watershed. Since October 2002, PacifiCorp has increased the pumping rate at JC-1 to more than 4,000 gpm. Thus, currently, the amount of groundwater being pumped into Electric Lake from JC-1 represents

Section 2.2: pages 2-61c, 2-61d

Lupinus alpestris	15.00	4.30
Osmorhiza occidentalis	4.00	2.74
Penstemon strictus	1.00	13.59
Viguiera multiflora	0.15	3.63
GRASSES[2)]		
Bromus carinatus	2.00	4.59
Elymus glaucus	2.00	5.05
Elymus trachycaulus	1.50	5.51
Festuca idahoensis	0.50	5.17
Festuca ovina	0.30	4.68
Phleum alpinum	0.50	11.48
Poa pratensis	0.10	5.00
Poa secunda	0.30	6.37
TOTALS	34.05	99.13
1)= Broadcast Rate 2)= Species changes may be made by a qualified botanist based on availability. PLS = Pure Live Seed AC = Acre FT^2 = Square Feet		

2.7.6 VEGETATION OF THE NORTH LEASE TRACT AREA

The North Lease Tract Area is located adjacent to the northernmost boundaries of the current Skyline Mine permit area. Much of this area is located within and adjacent to Winter Quarters Canyon.

The Winter Quarters Ventilation Facility (WQVF) is the only surface disturbance in the North Lease. ~~Because no surface disturbance is planned for this area, no quantitative data were compiled of the vegetation. Alnstead, a~~ A review of the existing information and data of the North Lease Tract and adjacent areas was done as the North Lease was permitted. Subsequently, a detailed vegetation survey has been conducted in Winter Quarters Canyon in the vicinity of the WQVF.. -

During August 2002 aerial photographs, collecting both infrared and black and white images, were taken of the North Lease Tract area to provide baseline vegetation data. Aerial photographs are taken annually, and will continue to be taken to detected variances from the baseline. Annual photographs will be interpreted by a qualified person and a report prepared for inclusion in the annual report.

PLANT COMMUNITIES

A report was prepared earlier by *Mt. Nebo Scientific, Inc.* (Collins 1992) of the vegetation of the Winter

Quarters Canyon area (North Lease Tract Area). This report was submitted to the USDA Forest Service. The report has been included in Appendix A-2.

Methodologies for this previous study relied on general vegetation mapping done by using existing information and limited ground-truthing techniques. Most of the mapping was done using existing maps and data from range analyses prepared by the USDA Forest Service (Manti-LaSal National Forest, Price, Utah).

Plant community named in the aforementioned study were revised to be consistent with the existing vegetation map of the permit area (Drawing 2.7.1-1a). The existing vegetation map of the area was revised using both black and white and color aerial photography. No field work or ground-truthing methods were implemented.

In October 2002 the vegetation at specific sites along the perennial streams within the North Lease was ground-truthed. This information is included in Appendix A-2 titled, "Riparian Plant Community Survey near Scofield, Utah - Winter Quarters and Woods Canyon 2002". Also in Appendix A-2 is "Biological Studies in Winter Quarters Canyon Creek and Woods Canyon Creek - A Study Plan" dated April 2005. The Study Plan outlines the method to be used to collect both qualitative and quantitative data to delineate areas of riparian vegetation. Using USFS Level III protocol transect lines will be established perpendicular to the stream channel at approximately 800-foot intervals for a baseline vegetation survey. Two years prior to longwall undermining any section of perennial streams, the transect interval will be increased to approximately 400-feet and surveyed each subsequent year through two years after mining has been completed for each longwall panel. The combined increase in transect interval and surveying the transects on an annual basis will provide adequate monitoring of the riparian areas. In addition, since riparian vegetation is closely related to the available flow in the perennial sections of the stream, additional flow monitoring sites have been established in the perennial sections of the stream that correspond to the longwall panels and areas of possible subsidence (See section 2.4.4 for monitoring plan details, Figure 2.3.6-2 for locations).Subsequent to the data collection outlined in the "Biological Studies Plan" in 2005, the baseline information will be submitted to the Division, to be included in Appendix A-2. All additional information will be submitted on an annual basis or as the information becomes available. The survey was expanded in 2010 to include additional portions of Woods Canyon Creek.

Aspen

The Aspen community was the most common vegetation type of the Winter Quarters Tract Area.

Section 2.8: pages 2-67,2-71a

Huntington Creek has a diverse aquatic community with macroinvertebrate taxa representing all trophic levels. The successful cutthroat trout spawning and high number of resident trout evidence the high quality waters and habitat of Huntington Creek plus the ability of the macroinvertebrate community to support quality fisheries. Cutthroat trout, according to Utah Division of Wildlife Resources (UDWR) surveys, are increasing in numbers in Huntington Creek above Electric Lake. Trout produced in Huntington Creek provide an important part of the total number of fish in Electric Lake.

Winter Quarters Canyon Creek

As indicated in the 1995 environmental assessment prepared by the Forest Service and the Bureau of Land Management Winters Quarters Canyon Creek has a moderate population of macroinvertebrates. Perennial flow in the canyon has produced Stonefly larvae as far up as Box and Bob's Canyons. Mayfly nymphs were also found present in waters tested. Cutthroat trout were found within the creek east of the Forest Boundary on June 7, 1994 indicating fish are likely within perennial sections of the creek containing significant flows. A survey conducted in Winter Quarters Canyon Creek in October 2002 indicated similar conditions and species (See Appendix Volume A-3, Volume 2). The Winter Quarters Ventilation Facility pad was specifically designed to minimized any potential impacts to the stream. The pad was designed to stay a minimum of two(2) stream widths from the stream, (or approximately 24 feet), thus maintaining a buffer zone and avoiding impacts to both the stream and riparian areas. The macroinvertebrates are monitored on a scheduled basis to insure the health of the stream (see Plate 2.8.1-1 for locations, Table 2.8-1a for monitoring frequency). Refer to Section2.4.3 - sediment yield and next section for measures implemented to construct in the stream buffer zone.

Woods Canyon Creek

As indicated in the 1995 Environmental Assessment, Mayfly nymphs were found within the upper portions of Woods Canyon Creek in higher quantities than those found within Winter Quarters Canyon. Stonefly larvae were also found as high as the fork in the stream near the center of Section 34 (T 12 S, R 6 E). No fish were seen during the 1994 field survey although some may have been present. A survey conducted in Woods Canyon Creek in October 2002 indicated similar conditions (See Appendix Volume A-3, Volume 2). As mining progressed north of Winter Quarters Canyon, the longwall panel orientation was rotated 90 degrees to maximize coal recovery. This rotation expanded mining approximately ½ mile to the east. To accommodate this modification, addional macroinvertebrate and fish monitoring locations were set up to insure monitoring stations are established downstream of mining activities to fully evaluate any impacts from mining. Details are outlined later in this section.

UP Canyon - Scofield Waste Rock site

The Scofield Waste Rock site is located in UP Canyon at the confluence of two ephemeral unnamed drainages. No aquatic wildlife habitat has been noted in either drainage.

magnification. The mean, standard deviation, density per square meter, and standing crop will be calculated and estimated using the same methods as in previous analysis.

Calculations of the USFS Biotic Condition Index (Winget and Mangum 1979) will be completed using the abundances of the benthic taxa to generate the dominance weighted community tolerant quotient (CTQd). The predicted community tolerant quotient (CTQp) will be calculated using water chemistry data provided in Winget (1972) for the Huntington Creek drainage.

Cluster analysis will be run using the Bray-Curtis dissimilarity index with the UPGM clustering algorithm.

Winter Quarters Canyon and Woods Canyon Creeks

From Fall of 2002 through early Summer of 2004 fish and baseline macroinvertebrate data for the perennial reaches within Winter Quarters Canyon and Woods Canyon Creeks in the North Lease area were gathered. Copies of the reports are included in Appendix Volume A-3, Volume 2.

A macroinvertebrate survey of portions of Winter Quarters Canyon and Woods Canyon Creeks will be performed twice a year for two consecutive years and then every third year thereafter or for a period determined by Canyon Fuel Company, LLC, DOGM, USFS, and the DWR, to be long enough to provide data to establish population trends. This survey will be performed in the fall and spring of each year on or about the same date.

In 2010 the Winter Quarters Ventilation Facility (WQVF) was added to the permit area approximately ½ mile downstream of the existing macroinvertebrate monitoring stations. Consultation with Dr. Shiozawa who directs the Skyline marcoinvertebrate monitoring program, indicated the portion of stream in the vicinity of the WQVF pad is not conducive to a macroinvertebrate study due to low gradient and inundation of fine sediment. He recommended a electro-fishing monitoring program which is outlined later in this section.

– As mining progressed north of Winter Quarters Canyon, the longwall panel orientation was rotated 90 degrees to maximize coal recovery. This rotation expanded mining approximately ½ mile to the east. To accommodate this modification, additional macroinvertebrate and fish monitoring locations were set up in Woods Canyon to insure monitoring stations are established downstream of mining activities to fully evaluate any impacts from mining. An additional electro-fishing monitoring program was added to Woods Canyon creek in 2010. Future sampling will be based on the results of the 2010 survey.

The following methods have been and will be used for macroinvertebrate sampling. Slight variations to the methods may occur during the field work or based on comments from regulatory agencies.

Three benthic sites will be sampled in each creek. Following the first survey a map with these stations will be prepared and submitted with the next sample report (included in the following year's annual report). Quantitative samples will be taken with a modified box sampler. The samples taken will be field preserved in 70% ethyl alcohol and returned to the laboratory for processing. The samples will be sorted and invertebrates identified to the lowest possible taxonomic level using the keys of Merritt and Cummins (1996). Those of questionable identity will be further examined and identified under magnification. The mean, standard deviation, density per square meter, and

Section 4.17: pages 4-92, 4-93, 4-94, 4-95a, 4-95c the Lower O'Connor "A"(See Section 4.17.3 Subsidence Prevention Measures). No buildings, pipelines, or maintained roads were found in the areas to be subsided as a result of implementing the ~~current~~ North Lease mine plan. The only mapped pack trail in the North Lease area runs east-west on the ridge between Winter Quarters Canyon and Woods Canyon, dropping down into Winter Quarters Canyon. The trail is outside the area to be subsided, therefore, no subsidence related impact is anticipated on the trail. In 2010 the panels located north of the Winter Quarters Canyon graben (North-of-Graben), were rotated 90 degrees to maximize coal recovery further east that originally outlined in 2002. The modification did not impact any additional buildings, pipelines or maintained roads with the additional acreage being undermined. —

As discussed in detail in Section 2.2 of this M&RP, the rocks in the North Lease area are in compression. The state of compression of the rocks in the North Lease area will likely allow the subsidence forces to be transmitted across fault and fracture planes thus resulting in uniform subsidence. Previous mining in Mine #3, where the rocks are also under compression, did not result in focused subsidence along faults or fractures. Indeed, in the southern portion of the mine permit area where the rocks are subjected to extensional forces, focused subsidence did not take place.

Drilling and field work conducted in the North Lease by Skyline geologist Mr. Mark Bunnell indicates the Castlegate Sandstone in the head of Winter Quarters and Woods Canyons in the permit area consist of two thin sandstone units, separated by slope-forming shale and siltstone. Because of the thinner, "ledge and slope" nature of the Castlegate in the permit area, the potential for subsidence-induced escarpment failures or landslides is minimal (3/3/05 M.Bunnell memo). As discussed in Section 4.17.3 and illustrated in Drawing 4.17.3-1A, the combination of geology, depth of cover, and mine plan should keep subsidence affects to a minimum (See Section 2.2 for detailed geology discussion). Drawings 4.17.1-1 and 4.17.1-2 illustrate that, if the maximum subsidence does occur, no reduction or significant alteration of the perennial stream flow should occur. This is due primarily to the existing stream gradient, projected worst-case subsidence, depth of cover, and depth of alluvium within the drainage corridor. Although the gradient is reduced in some areas, no significant ponding or over-steepening of the gradient is anticipated. Potential areas of *minor* cracking, as illustrated on Drawing 4.17.3-1A, are primarily a function of the advancement direction of the longwall panel, steepness of slope, the lack of confining pressure, and how the bedrock subsides into the void left by longwall mining.

The mine will not subside any of the perennial streams in the North Lease without approval from the Forest and Division. The rotating of the panels north of the Winter Quarters Canyon graben in 2010 did not impact the undermining of the portions of perennial streams on the Manti-La Sal Forest. The Burnout Canyon Study (Appendix A-1, Volume 2), conducted in cooperation with Canyon Fuel Company, LLC, and The Manti-La S~~s~~al National Forest, was completed in July 1998. Quoting the Burnout Final Report, "This study was initiated in 1992...to address the effects of longwall minnig and related subsidence in the Wasatch Pleateau on hydrology, channel condition and habitat changes in perennial and intermittent reaches of a mountain stream." The Burnout Canyon study concluded that any changes in flow in Burnout Creek areas were likely related to climatic changes (drought) and not mining activities (DOGM EDI). The stratigraphy, depth of cover, and general dip of the formations in Woods and Winter Quarters Canyons are very similar to Burnout Canyon (See sections 2.3.1, 2.5, 4.17.3, and Appendix A-1, Volume 2 for details). The permittee believes the Burnout Canyon Study can be used to predict the impacts of undermining both Winter Quarters and Woods Canyons and that mining in the North Lease area can be conducted with minimal impacts to perennial streams due to subsidence.

The Forest has indicated that the forest land is considered to have renewable resources related to wildlife and grazing. The timber resources are extremely limited and isolated in this area of the forest and will likely never be harvested (Carter Reed, Manti-La Sal National Forest, Oral Communication 10-2002).

Included in the Subsidence Probability Survey for Woods Canyon, Skyline contracted Agapito Associates, Inc. (AAI) to evaluate the subsidence impacts of conducting full-extraction mining in areas with as little as 400 feet of overburden (Appendix A-1, Vol. 2). The AAI analysis utilizes a numerical model - Surface Deformation Prediction System (SDPS)(Agiotuantis and Karmis 2002)that incorporates, information from the Burnout Canyon Area study, local geology, mining and subsidence data. The study predicted less than five (5) feet of subsidence would occur in the Woods Canyon area and mining could safely be conducted in areas with 475 feet of overburden. Other items identified in the AAI study include: 1) the average gradient in Woods Canyon (5.71%) is greater than in Burnout Canyon (4.12%) which suggests the horizontal strain will be spread along a longer stream path and dampen direct impacts of tensile strain; and 2) the US Bureau of Mines (USBM) criteria for subsidence classifies Wood Canyon as having class III (shaley and silty sandstone) overburden, and the appropriate overburden thickness multiplier would be 461 feet. Incidentally, the same USBM report (1979) originated the 60 times the extraction thickness rule-of-thumb. However, this criteria was meant to be applied only to extraction below bodies of water of 'catastrophic' potential size such as large rivers and lakes. The 60 times the extraction thickness is a conservative generalization that somewhat mis-characterizes the USBM study recommendations.

4.17.2 Mining Methods

The mining methods to be used by the Permittee include longwall mining, room and pillar mining with pillar removal, and room and pillar mining with pillars left in place. Certain room and pillar mining systems are designed to provide full support and will prevent subsidence. Subsection 3.1.5 contains descriptions of the mining methods to be implemented.

Full extraction areas include room and pillar panels with pillar removal and longwall panels. Subsidence prediction work has shown the expected maximum planned and controlled subsidence will vary from 0 to 24 feet, assuming that the total cumulative extraction from the three mineable seams will not exceed 30 feet.

4.17.3 Subsidence Effect Prevention Measures

It is anticipated that the planned subsidence will result in a generally uniform lowering of the surface lands in broad areas, thereby limiting the extent of material effect to those lands and causing no appreciable change to present land uses and renewable resources. The Permittee established a subsidence monitoring program in the early stage of mining for use in reviewing the surface effect of mining and as an aid in future mine planning.

In areas where mining related subsidence would damage resources, room and pillar mining methods will be used. Wherever the pipeline and creek buffer zones coincide, creek buffer zone requirements take precedence. Where the yield pillar/barrier system is used, the measures will be taken to ensure no surface subsidence is induced due to failure of the entries, as mutually agreed with regulatory agencies. The entries in Skyline Mine No. 2 will enter the Huntington Creek buffer zone for a short distance as approved by the Division/U.S. Forest Service

No mining will be conducted beneath Electric Lake.

Full extration mining techniques under the creek buffer zones will only be proposed if evidence shows surface effects, if any, can be mitigated. Full extraction mining techniques and associated mitigation plans must first be approved by the Division/U.S. Forest Service.

Drill holes show that there are clay rich shale layers present which will likely swell into an impervious clay when wet. This characteristic is expected to seal possible subsidence cracks to prevent downward migration of water and subsequent loss of springs and other water sources based on information supplied by Roy Full (Volume A-3)and supported by the Burnout Canyon Study (Appendix 1-A, Vol.2).

Extensive experience with mining-induced subsidence at Skyline Mine indicates the subsidence factor (SF) relative to mining height is as follows:

Overburden 200-500' ~ SF 0.7
Overburden 500-1000' ~ SF 0.5
Overburden 1000-1500' ~ SF 0.3
Overburden 1500-2000' ~ SF 0.15

Approximately 20-30 percent of the planned subsidence will be occurring where overburden thickness ranges from 500 to 1000 ft. and 70-80 percent of the subsidence occurring where overburden thicknesses are greater than 1000 ft(3/3/05 M. Bunnell memo). Given the projected mining thickness is 9-11 feet, and the approximate minimum overburden is 600 feet in the North Lease area, the maximum subsidence anticipated is less than 6 feet. Drawing 4.17.3-1A illustrates most of the subsidence will be in the 2 to 4 ft. range. Areas identified as having 6-feet of subsidence were rounded-upward to provide a six-foot contour line. Six-feet of subsidence is generally a worse-case scenario. The subsidence factor identified above suggests subsidence in the range of seven (7) feet could be seen in Woods Canyon. Through 2009, this has been a conservative factor since the most subsidence that has been noted is approximately four (4) feet in Winter Quarters Canyon and its tributaries. The AAI modeling report in Appendix A-1, Volume 2 suggest subsidence will remain less than six (6)feet even in areas with 500 feet of overburden.

In 2010 full extraction mining in Woods Canyon was extended ½ mile further east into areas with less than 600 feet of overburden. As a mitigation effort to monitor subsidence, a total of nine (9) piezometers or shallow groundwater wells have been established adjacent to the creek starting at the USFS boundary and extending east of the proposed mining. The piezometers were established to monitor the shallow groundwater adjacent to the stream to both determine whether Woods Canyon Creek is an gaining or losing stream, and to gauge any flow impacts associated with mining.

If it is determined that subsidence causes material damage or a loss of flow in a perennial stream, the Permittee commits to using the best technology currently available (BTCA)to mitigate the damage. Methods may include backfilling with surrounding native material, incorporating bentonite or other water-retaining native material into the backfill, or possibly even temporarily bypassing/piping flow through impacted areas until mitigation is achieved.

Section 4.17: REMOVE plate 4.17.1-1 from text

Plates 1.6-1, 1.6-3, 2.2.1-1, 2.2.7-7, 2.3.4-2, 2.3.6-1, 2.3.6-2, 2.8.1-1, 3.1.8-2, 3.3-2, 4.17.1-1,4.17.3-1A.

Appendix Volume A-1, Volume 2; Addition to 2004 Woods Canyon GPS survey, Earthfax Engineering, Inc. 2010 (ADD TEXT TO 2004 REPORT)

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September 7, 2010

Mr. Gregg Galecki
Canyon Fuels Company, LLC
P.O. Box 719
Helper, Utah 84526

Dear Gregg:

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Thank you for the opportunity to provide this service to the Canyon Fuel Company, Skyline Mine. If you have any questions or need more information, please do not hesitate to contact me.

Sincerely,

L. DS

Larry DuShane
EarthFax Engineering, Inc.

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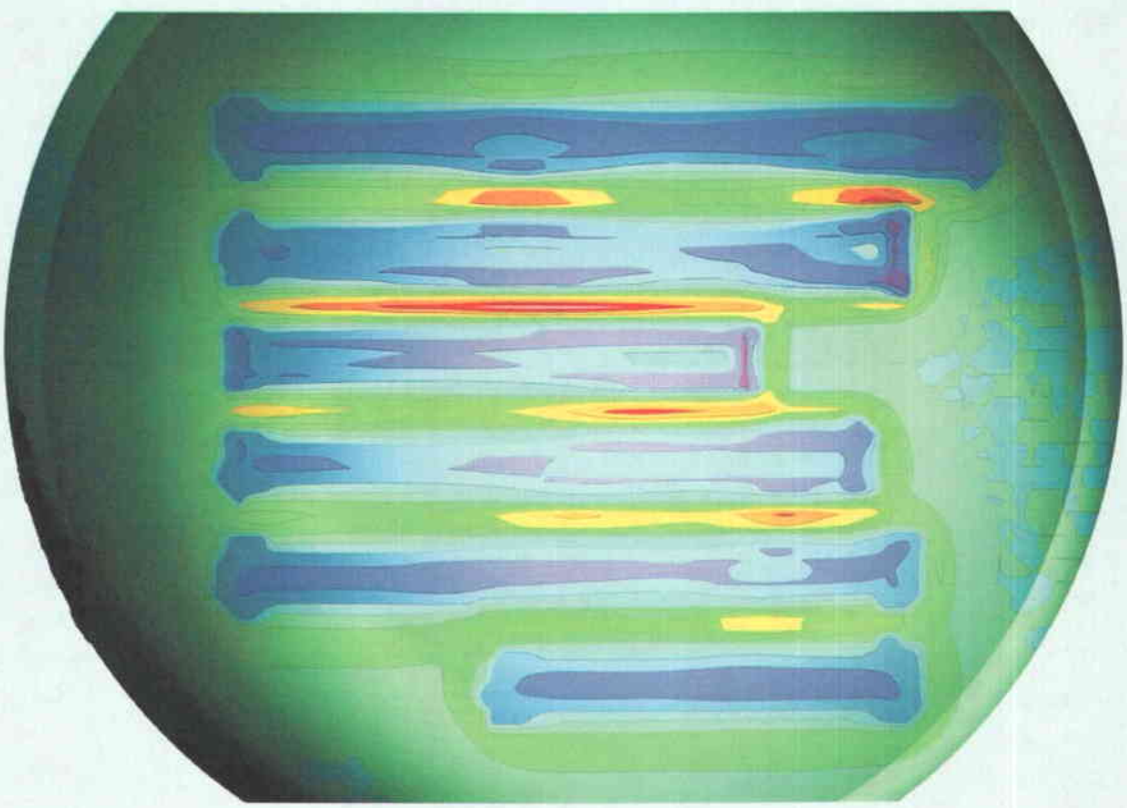
Appendix Volume A-1, Volume 2; 2004 Woods Canyon GPS survey, Earthfax Engineering June 29, 2004, REPLACE Plates 1 and 2.

Appendix Volume A-1, Volume 2: Woods Canyon Subsidence Study, Skyline; Agapito Associates, Inc. June 2010

Woods Canyon Subsidence Study, Skyline Mine

Prepared for

Canyon Fuel Company, LLC



June 2010

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WOODS CANYON SUBSIDENCE STUDY
SKYLINE MINE

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***DISCLAIMER:** This report contains professional opinions based on information provided by the Owner. AAI makes no warranties, either expressed or implied, as to the accuracy or completeness of the information herein. Opinions are based on subjective interpretations of geologic data; other equally valid interpretations may exist. Identification and control of hazardous conditions are the responsibilities of the Owner.*

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WOODS CANYON SUBSIDENCE STUDY
SKYLINE MINE

1.0 INTRODUCTION

Agapito Associates, Inc. (AAI) was contracted by Canyon Fuel Company, LLC (CFC) to investigate the potential impacts of subsidence due to longwall mining under Woods Canyon, at its Skyline Mine (Skyline) near Scofield, Utah. As part of the Woods Canyon analysis, AAI back analyzed longwall-mining-induced subsidence for the Burnout and James Canyon areas.

Skyline Mine plans to mine eight retreat longwall panels in the Lower O'Connor A seam, numbered "8L" through "15L." In the current mine plan, panel 11L and portions of panel 12L underlie Woods Canyon, which is a perennial stream. The stream has a general flow direction of west to east (Figure 1). Panel 11L retreats from a cover depth of approximately 1,000 feet (ft) to a cover depth of 600 ft. CFC would like to have a better understanding of potential subsidence impacts to the stream and explore the possibility of continuing mining in Panel 11L further to the east, to possibly as little as 400 ft of cover.

The investigation was carried out as follows:

1. Develop subsidence input parameters based on the review and calibration of historic geologic, mining, and subsidence data.

2. Develop numerical models and perform back-analysis for James Canyon and Burnout Canyon, and forward analysis for Woods Canyon, using site-specific mining geometries and variable cover depths. Model results provideground subsidence and associated surface deformation indices such as subsidence, strain, slope, and curvature.

3. Compare ground subsidence and deformation indices from historic mining to Woods Canyon indices to assess the potential impacts of surface deformation on Woods Canyon.

4. Review western experience and surface water damage criteria regarding minimum depth of cover to minimize liklihood of communication between mine workings and the Woods Canyon stream bed.

AAI's approach consisted of two separate elements. The subsidence modeling, using the program Surface Deformation Prediction System (SDPS) (Agioutantis and Karmis 2002) was used to evaluate potential impacts to the Woods Canyon drainage resulting from deformation at the ground surface. Then, empirical surface water damage criteria were used to account for subsidence processes that occur in the overburden, including potential development of water pathways between the mine and the stream bed. Potential communication of stream water through the overburden is not addressed in SDPS, and is dependent on depth of cover and overburden material properties.

2.0 BACKGROUND INFORMATION

Two of the currently proposed longwall panels (11L and 12L) are overlain by a perennial stream in Woods Canyon. The stream flows from west to east and is oriented approximately parallel to the long axis of panel 11L (Figure 1). The adjacent panels (8L, 9L, 10L, and 13L) are overlain by tributaries to the Woods Canyon stream. The depth of cover for the subject panels varies from 600 ft to 1,300 ft. The currently planned stop line for panel 11L is under approximately 600 ft of cover. CFC is interested in exploring the possibility of extending the stop line to shallower cover depths, down to 400 ft, directly under Woods Canyon, assuming that the current layout could be altered to allow it.

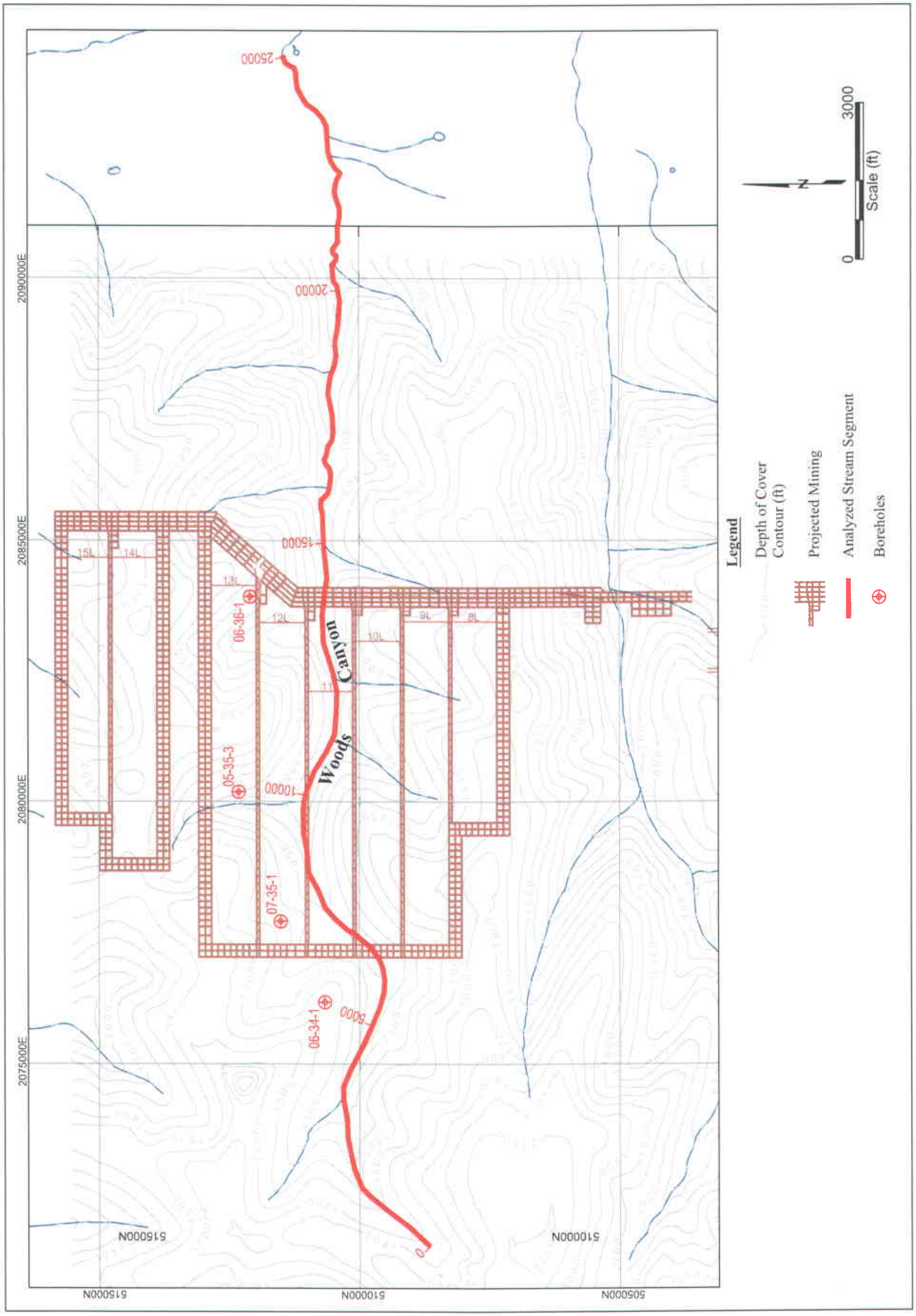
The planned extraction thickness for all panels is approximately 10 ft. Review of logs from selected boreholes in the Woods Canyon area (Figure 1) indicated that the overburden rock mass is composed of approximately 90% or more hard rock (a combination of sandstone and siltstone). The presence of strata such as claystone and shale in the overburden strata is limited. The aforementioned lithologic logs are presented in the Appendix.

Skyline mined the Upper O'Connor (UO seam, Mine 1) and Lower O'Connor B (LOB seam, Mine 2) seams a few miles south of the current area of interest. In total, 12 panels were mined in the UO seam and 15 panels were mined in the LOB seam. Extraction thicknesses for both the seams varied from approximately 8.5 ft to 12.5 ft. The average percentage of hard rock in the overburden, based on logs from selected boreholes (Figure 2a), was estimated to be 75% (see Appendix for lithologic logs). Interburden thickness between the mined panels varied from approximately 35 ft to 65 ft. Portions of the mined panels were overlain by perennial streams in Burnout Canyon and James Canyon (Figure 2a). Mine 1 (UO Seam) panels under Burnout Canyon were mined during 1989–1998. Mine 2 (LOB Seam) panels were mined during 1996–2003. Following mining of both the seams, aerial surveys were conducted to record change in surface topography due to mining-induced subsidence. The measured subsidence contours are presented in Figure 2b.

A study investigating the impacts of subsidence on the Burnout Canyon and James Canyon streams was conducted during 1992–1997 (Forestry Sciences Laboratory 1998). The study found no effects of subsidence-induced changes in most of the stream characteristics. Specifically, streamflow in both the drainages was unaffected during the study period. The only exceptions were noticeable changes in the proportion of cascades and number of pools.

3.0 INVESTIGATION APPROACH

AAI used the Burnout/James Canyon subsidence studies (Forestry Sciences Laboratory 1998), Skyline mine plans, pre-mining surface topography contours, and post-mining subsidence survey information to develop numerical models. These models were used to calibrate the subsidence parameters such as the subsidence factor (the ratio of maximum possible subsidence to extraction thickness), the influence angle (the angle between the projection of the inflection point to seam level, and the point of zero subsidence, as measured from horizontal), and the location of the inflection point (the zero curvature point on the surface subsidence profile) from the panel edge, otherwise known as "edge offset." A graphical representation of these parameters is presented in the Appendix.



260-37 Canyon Fuel Skyline [Figure 1.dwg Layout: Fig 1]sm/rjl(5-10-2010)

Figure 1. Projected Longwall Mining Layout under Woods Canyon

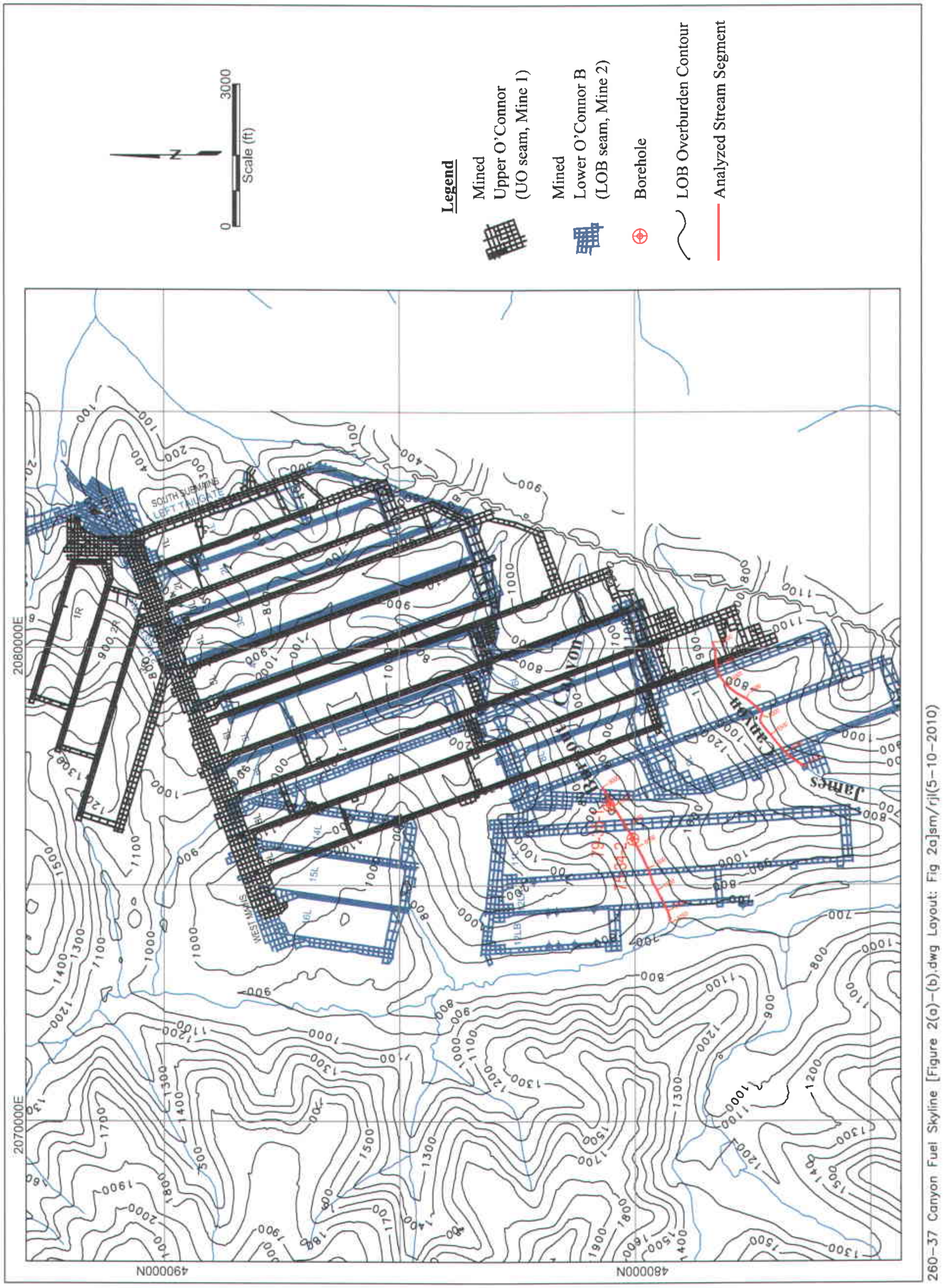


Figure 2a. Historic Longwall Mining Layout under Burnout Canyon and James Canyon with LOB Overburden Contours

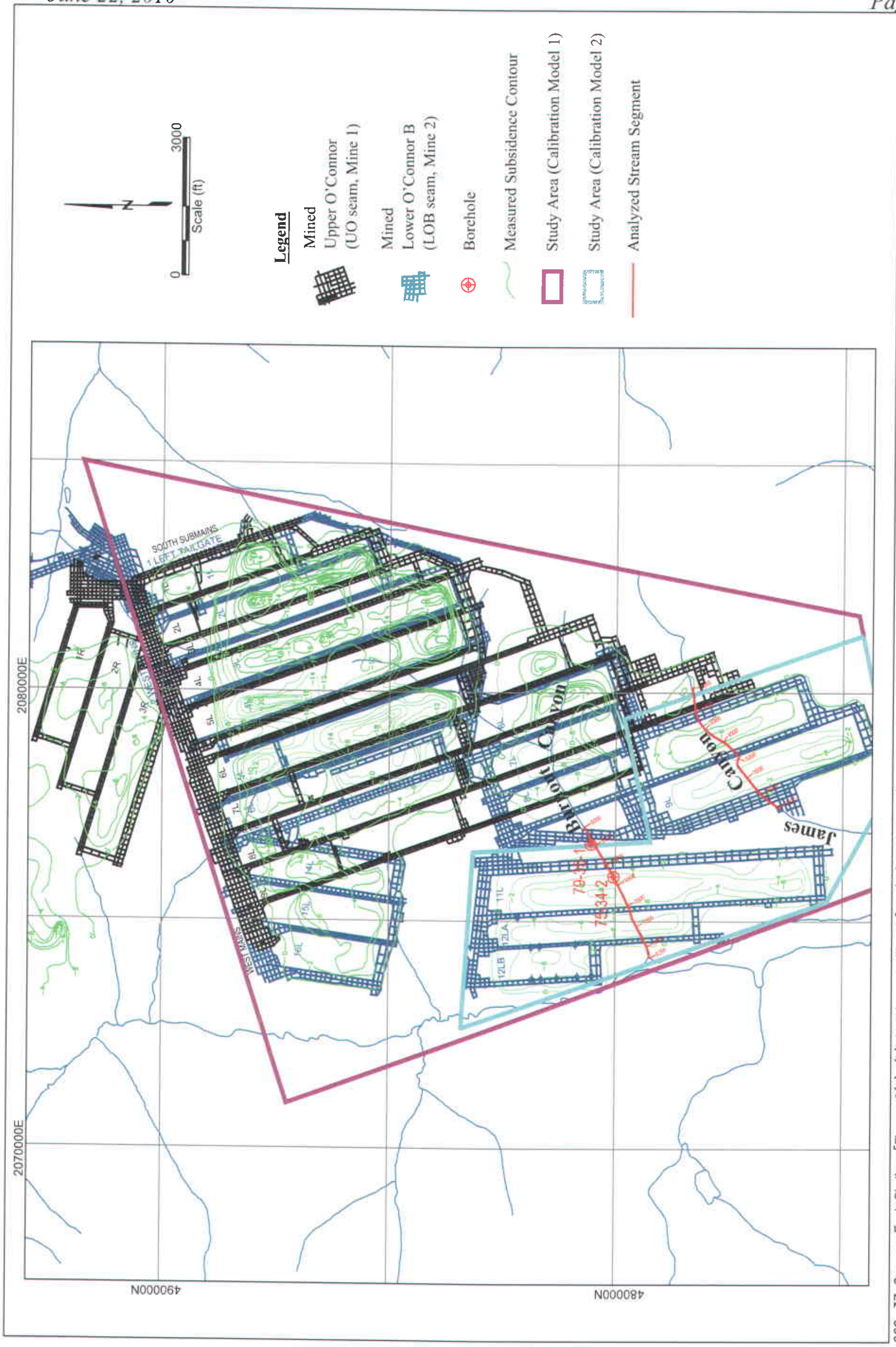


Figure 2b. Historic Longwall Mining Layout under Burnout Canyon and James Canyon with Measured Subsidence Contours

The subsidence parameters obtained from the calibration exercise were used to develop Surface Deformation Prediction System (SDPS) (Agioutantis and Karmis 2002) numerical models of multiple longwall layouts under Woods Canyon. Numerical analysis was performed on these layouts to assess their respective impacts on Woods Canyon, from a surface deformation point of view. Subsidence indices were estimated from the numerical analysis results, in order to characterize the predicted long-term subsidence. The subsidence indices were:

- Ground subsidence—the vertical displacement of a given point on the surface
- Horizontal strain—the change in horizontal distance between two points divided by the original horizontal distance between the points
- Slope—the difference in subsidence for two points divided by the horizontal distance between the points
- Curvature—the difference in slope for two points divided by the horizontal distance between the points

Note that slope is the derivative of subsidence with respect to distance and curvature is the derivative of slope with respect to distance or the second derivative of subsidence with respect to distance.

In addition, western subsidence experience and surface water damage criteria were reviewed regarding minimum cover depth between the mining horizon and the stream bed. The amount of cover and its properties affect the likelihood for communication (water pathways) from the surface to the caved zone above the extraction horizon. Soft overburden layers (clay, shale, mudstone, etc.) relatively close to the surface tend to obstruct such communication, while pathways are more likely to extend through layers composed of harder materials such as limestone, sandstone and siltstone. Communication is a separate issue not addressed in the numerical analysis, therefore empirical guidelines were applied.

4.0 NUMERICAL ANALYSIS

The "Influence Function" module of SDPS was used during this investigation. This program module uses an influence function method, which essentially assigns a mathematical expression (in this case, the bell-shaped Gaussian function) to predict subsidence distribution induced by excavation of a unit area. The influence function method has the ability to superpose the influences from multiple and irregular mine geometries. In addition to subsidence, this program also estimates subsidence indices such as strain, slope, and curvature.

4.1 Calibration of Measured Subsidence in the Burnout Canyon Area

Calibration of Burnout Canyon subsidence was accomplished by inputting longwall panel geometries from the UO and LOB into SDPS. In total, two calibration models were developed using SDPS. The first model incorporated all 15 longwall panels from the LOB seam (Mine 2) and 9 longwall panels from the UO seam (Mine 1). The northern 3 longwall panels (1R, 2R, and 3R) of the UO seam were excluded from this model due to their irregular orientation with respect to the other panels and the irregular subsidence trough formed over them. This model represented a multi-seam mining condition. In order to calibrate a single-seam mining condition comparable to the Woods Canyon mining area, a second model was developed that only included LOB seam panels 9L, 11L, 12LA, 12LB, and the southern half of 8L. The study areas for both the calibration models are outlined in Figure 2b.

Once the panel geometries were defined, overburden contours (with respect to the LOB seam) were imported into both the models in grid file format. The advantage of using a grid file format for the overburden contours was that the grid points with easting, northing, and elevation information also served as prediction points for subsidence. Finally, the subsidence contours were also imported into both the models in a grid file format with its grid points matching those of overburden contours. As a result, every prediction point had a measured value of subsidence assigned to it. Since the second model included only five longwall panels, both the overburden contour and subsidence contour grid files were trimmed to cover only those five panels.

Once the two calibration models were set up, calibration runs were made by providing wide initial ranges for three variables: the influence angle, the subsidence factor, and the edge offset. An initial model was then run, and from this model, the range of variables was narrowed with every iteration to arrive at a best-fit set of values for both the calibration models. The best-fit values of the influence angle, the subsidence factor, and the edge offset corresponded to the least sum of errors (magnitude differences) between predicted subsidence and measured subsidence values at each of the prediction points.

The best-fit values of the influence angle, the maximum subsidence factor, and the edge offset for the multiple-seam model (with 25 panels from both LOB and UO seams) were 59.5°, 0.62, and 107 ft, respectively. Measured subsidence values in excess of 20 ft, observed over multiple-seam mining areas, may appear to be incongruous with a subsidence factor of 0.62, given that the combined extraction thickness of both the seams is less than 24 ft. AAI considers it likely that some of this difference can be explained by variations in the aerial survey technique conducted over mountainous terrain.

The calibration runs for the single-seam (LOB) model yielded the optimum values of the influence angle, the maximum subsidence factor, and the edge offset to be 65.6°, 0.49, and 67.5 ft, respectively. The subsidence parameters obtained from the single-seam calibration model were considered more suitable for development of subsidence prediction models in Woods Canyon, owing to the fact that Woods Canyon mining will be single-seam mining.

Burnout Canyon has a similar overburden lithology, from a hard-rock percentage standpoint, to the Woods Canyon area. Hence, the influence angle and maximum subsidence factors were kept the same (65.6° and 0.49) for the Woods Canyon models. However, increased depth of cover in the Woods Canyon area led AAI to increase the edge-width parameter from 67.5 ft to 70 ft.

Finally, the deformation experienced along the drainages in Burnout Canyon and James Canyon overlying the five panels in the single-seam calibration model was plotted. Figure 3 presents the subsidence, the maximum horizontal strain, and the maximum curvature modeled for the Burnout Canyon drainage as it crosses panels 11L and 12LA. Figure 4 presents the same parameters modeled for the James Canyon drainage as it crosses panels 8L and 9L. In both figures, the subsidence indices are shown along the longitudinal section of the respective streams. The maximum subsidence predicted for both the streams is approximately 6 ft. The maximum tensile (positive) horizontal strain predicted for Burnout Canyon is approximately 18 millistrain and the maximum tensile horizontal strain predicted for the James Canyon is approximately 15.5 millistrain. These maximum tensile strain values are observed between two adjacent panels, due to the superposition of tensile strains generated by the mining of the individual underlying panels. Figures 3 and 4 also present the measured subsidence values along the Burnout Canyon and James Canyon streams, which compare fairly well to the modeled subsidence values.

4.2 Subsidence Prediction in Woods Canyon

Using the calibrated subsidence parameters discussed in the previous section, four subsidence predictive models were developed, representing four different mining scenarios, as follows:

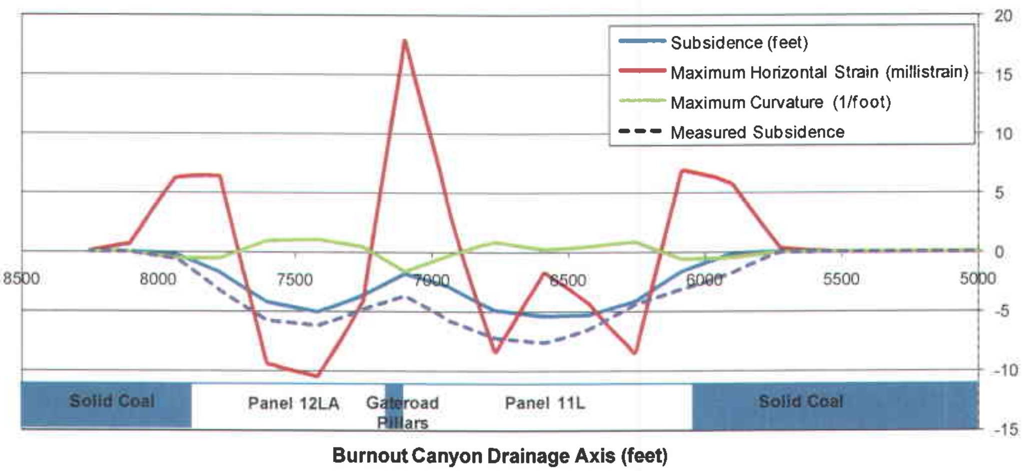


Figure 3. Mining-Induced Deformation along the Axis of Burnout Canyon (as it crosses Panels 11L and 12LA)

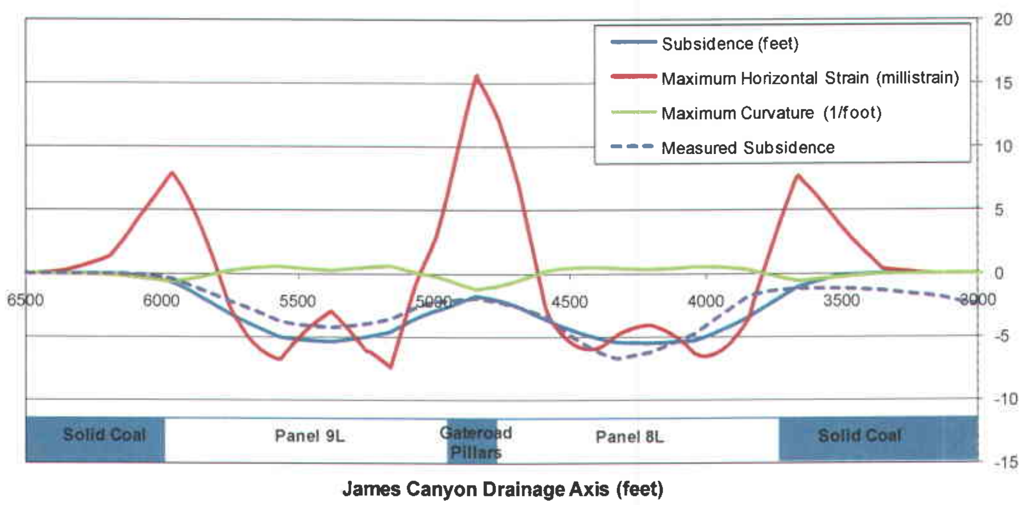


Figure 4. Mining-Induced Deformation along the Axis of James Canyon (as it crosses Panels 9L and 8L)

- Case 1: Panels 8L, 9L, 10L, and 11L have been mined to their currently projected boundaries on the east, and panels 12L and 13L are unmined (Figure 5). The cover depth for the 11L stop line is 600 ft.

- Case 2: All six panels have been mined to their current projections, with cover depth at the 11L stop line being 600 ft (Figure 5).

- Case 3: Panels 8L, 9L, and 10L have been mined to their eastern limits, panel 11L is mined to a cover depth of 400 ft (Figure 6), and panels 12L and 13L are unmined.

- Case 4: Panels 8L, 9L, 10L, and 11L mine with same stop lines as in the third model, and the stop lines of mined-out panels 12L and 13L are at the same easting as 11L (Figure 6).

The panel extraction was assumed to be 10 ft for all cases. An influence angle of 65.6°, a maximum subsidence factor of 0.49, and an edge offset of 70 ft were applied to all four models. The analysis results are discussed below.

The subsidence index plots for Case 1 are presented in Figures 7a–d. The ground subsidence contours associated with this case are shown in Figure 7a. Four distinct subsidence troughs are observed over the four mined-out panels and the maximum subsidence value is less than 5 ft. The maximum horizontal strain contours are plotted in Figure 7b. Compressive strains are observed toward the center of the subsidence troughs and the individual panels, with maximum values up to –7.5 millistrain. Tensile strains are present around the edges of the panels, and between them, with maximum values up to 15 millistrain. The high tensile strains between the eastern ends of panels 10L and 11L may be attributed to the sudden change in cover depth. Figure 7c presents the maximum curvature contours above mined-out panels. High negative curvatures are confined to the edges of the panels and high positive curvatures occur toward the centers, which correspond to the occurrence of high values of tensile and compressive strain, respectively. Maximum slope of the subsided ground is presented in Figure 7d, with the edges of panels exhibiting steeper slopes than the centers.

Figures 8a–d present the subsidence index plots for Case 2. In this case, panels 8L through 13L have been mined out to the currently-projected boundaries and panel 11L has been mined to a cover depth of 600 ft. The ground subsidence contours are shown in Figure 8a. Six distinct subsidence troughs are observed over the six mined-out panels and the maximum subsidence value is again less than 5 ft. The maximum horizontal strain contours (Figure 8b) show compressive strains toward the center of subsidence troughs and individual panels, with maximum values up to –10 millistrain. Tensile strains are present around the edges of the panels, subsidence troughs, and between them. The largest tensile strains, 15–17.5 millistrain, are observed between panels 11L and 12L, where Woods Canyon transits through. Again, such high tensile strains between panels 10L and 11L may be attributed to the sudden change in cover depth. Figure 8c presents maximum curvature contours. High negative curvatures are confined to the edges of the panels and high positive curvatures occur toward the centers, which correspond to the occurrence of high values of tensile and compressive strain, respectively. Maximum slope of the subsided ground is presented in Figure 8d, with the edges of panels exhibiting steeper slopes than the centers. The slopes are especially higher towards the eastern

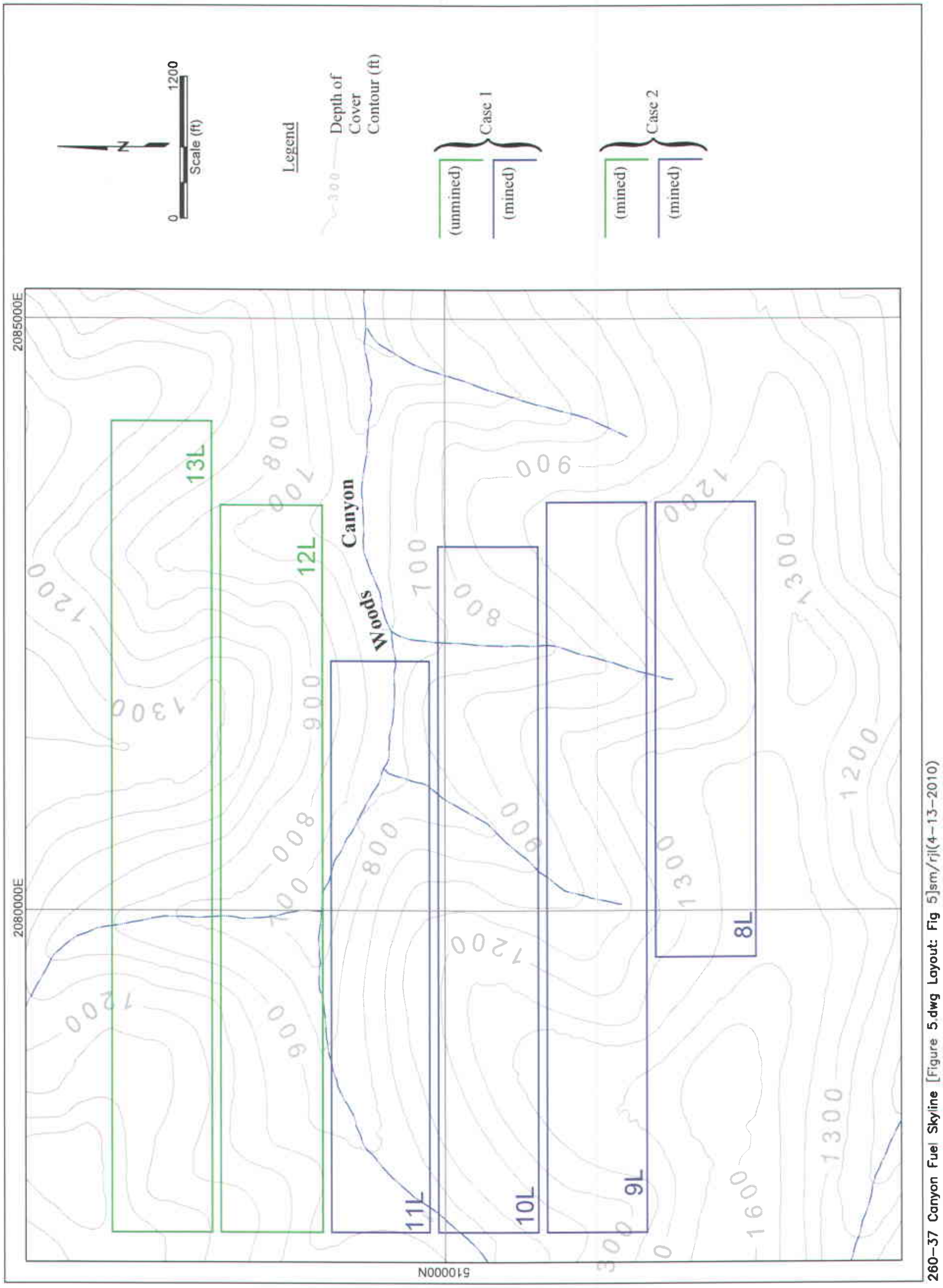


Figure 5. Longwall Mining Layout for Numerical Analysis. Case 1 and Case 2

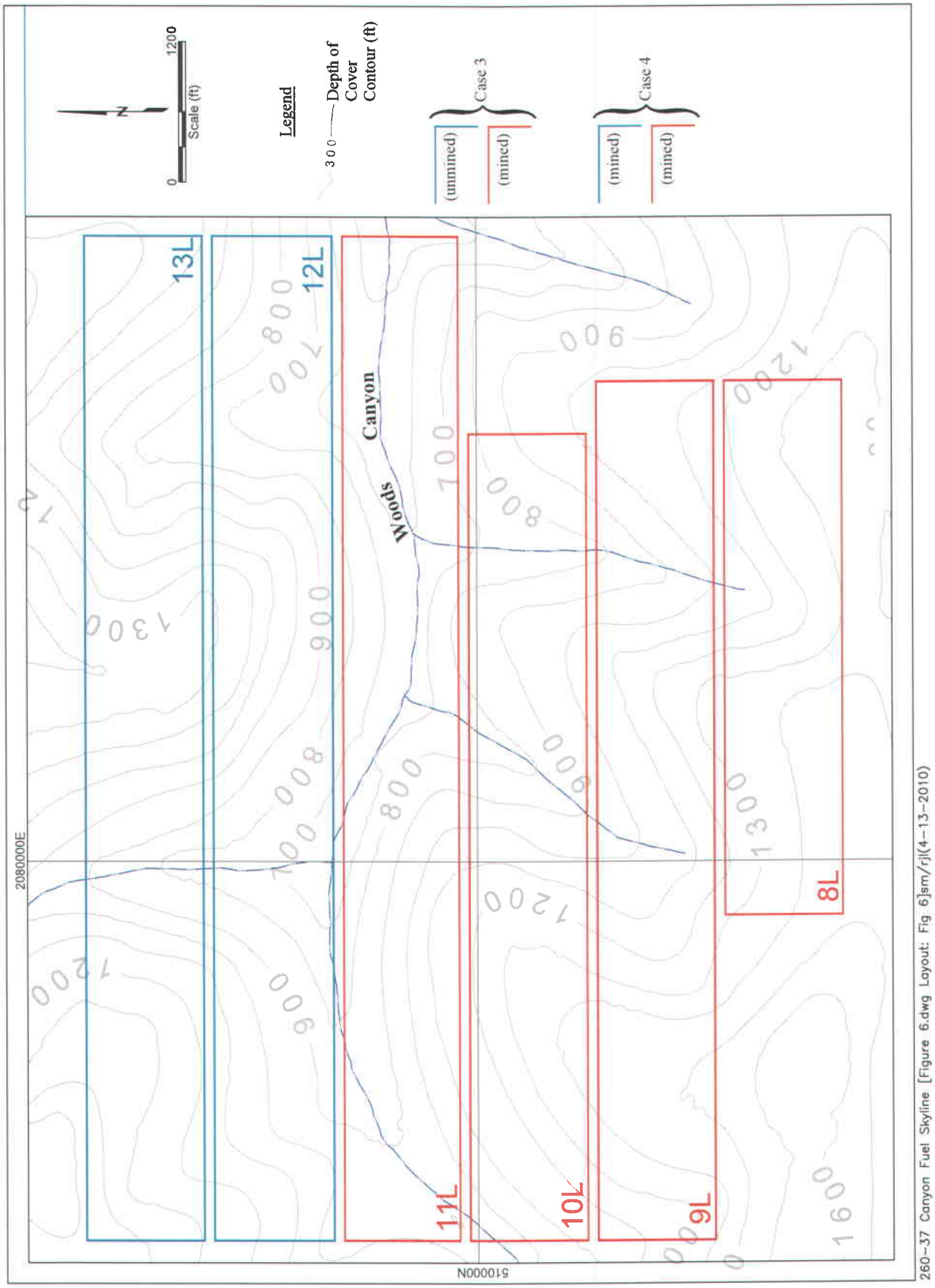
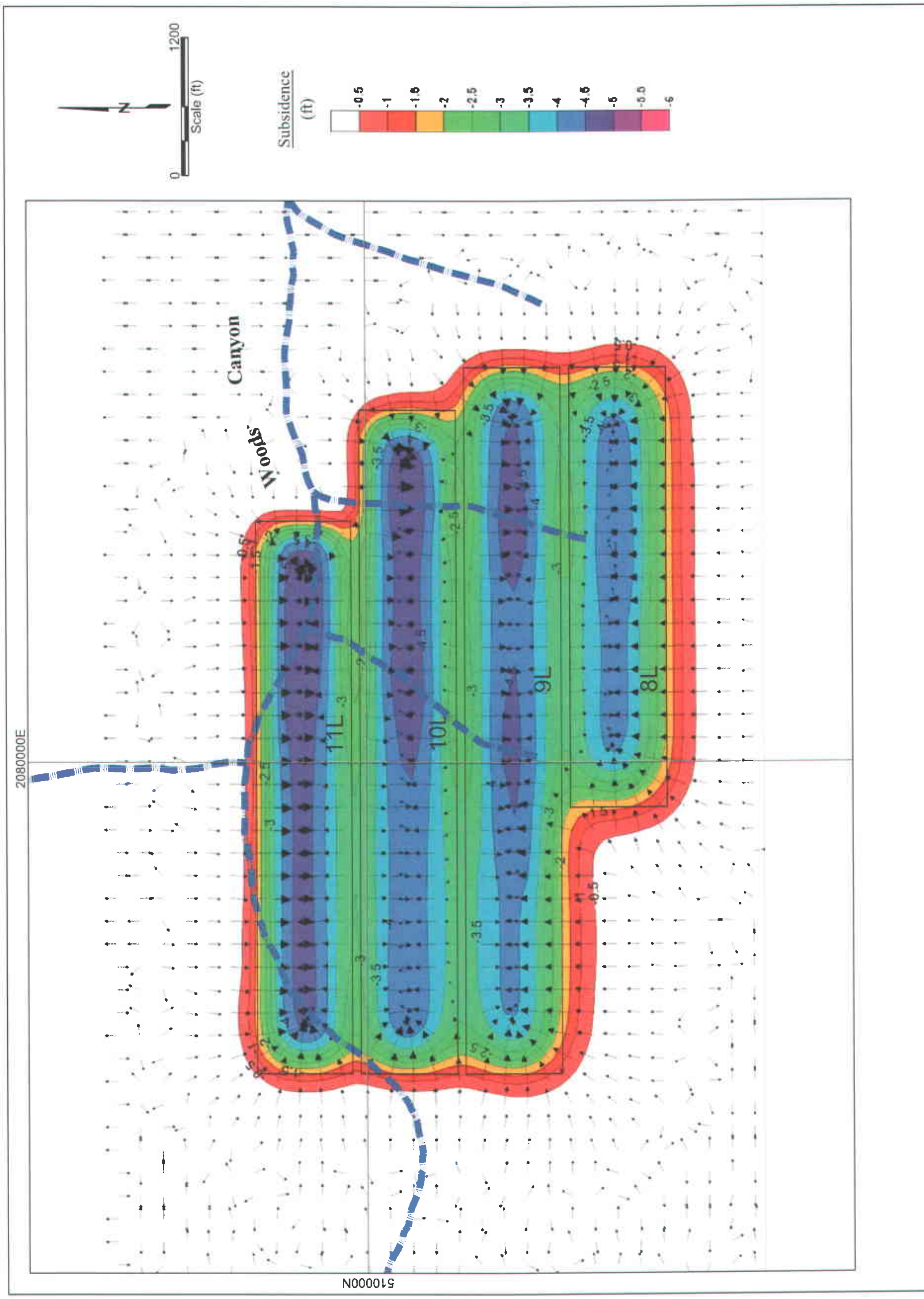
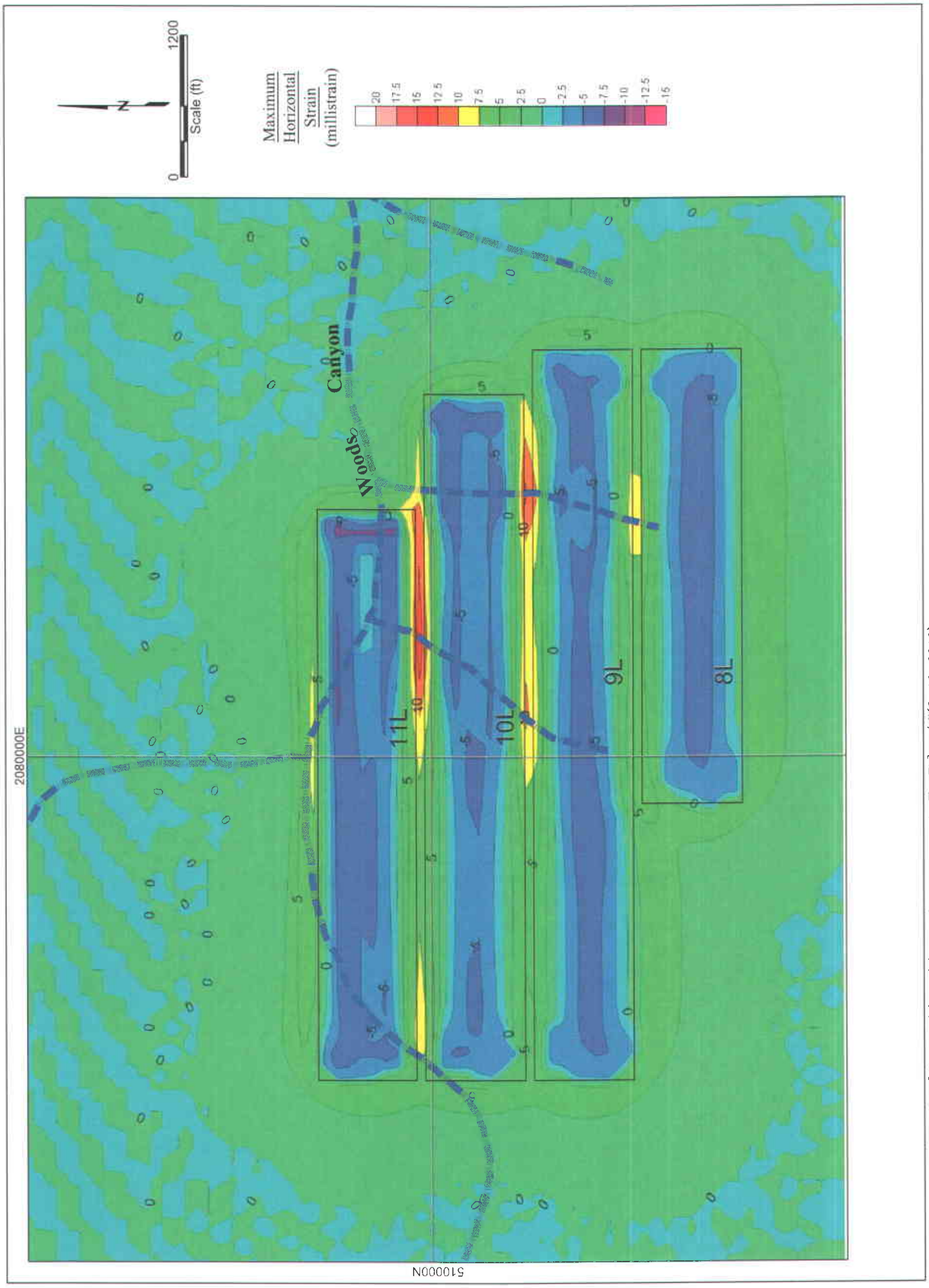


Figure 6. Longwall Mining Layout for Numerical Analysis, Case 3 and Case 4



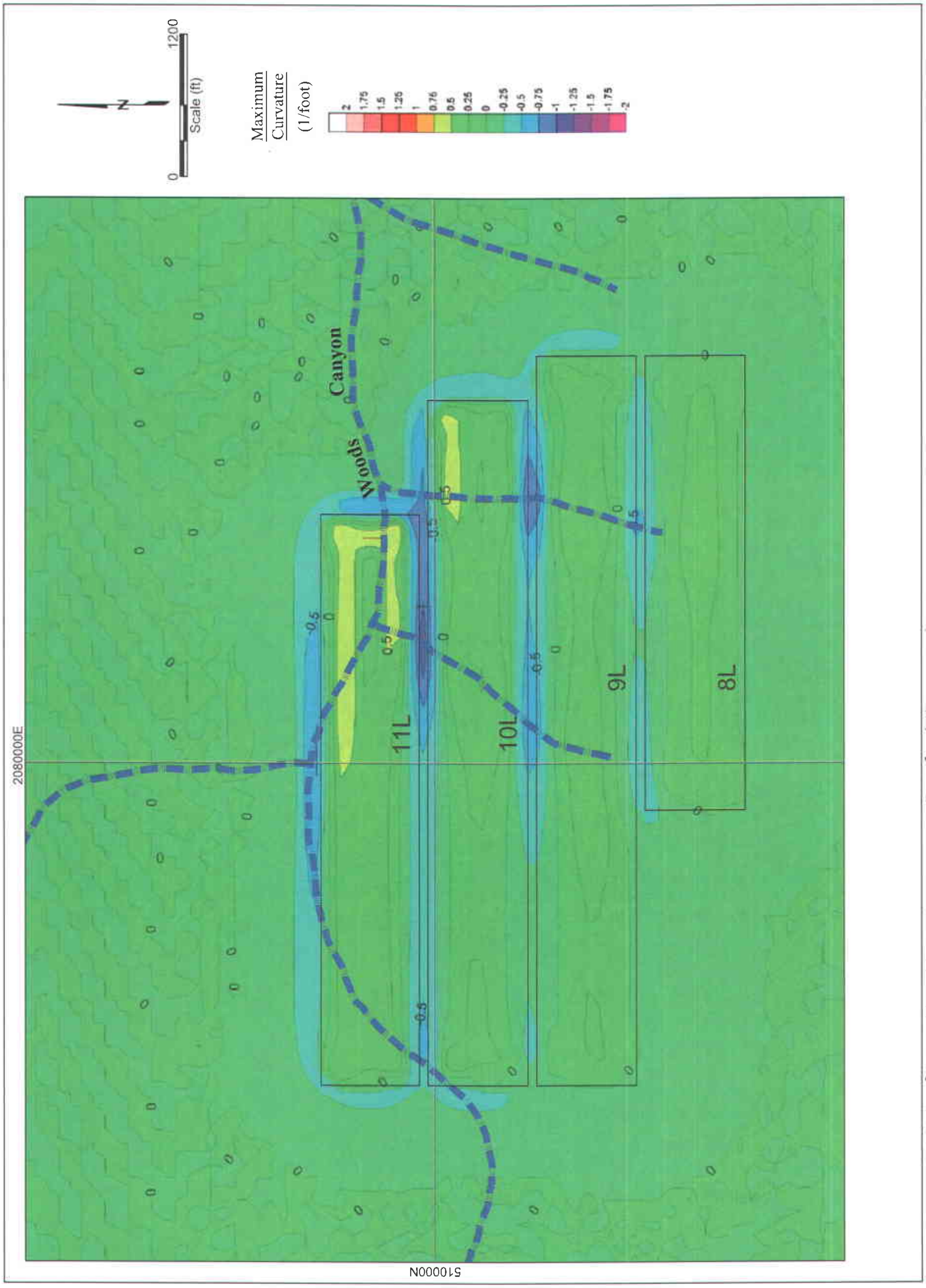
260-37 Canyon Fuel Skyline [Figure 7(a) - (d)_Model 1.dwg Layout: Fig 7a]sm/rjl(5-10-2010)

Figure 7a. Subsidence Contours for Case 1



260-37 Canyon Fuel Skyline [Figure 7(a) - (d)_Model 1.dwg Layout: Fig 7b]sm/rjl(5-10-2010)

Figure 7b. Maximum Horizontal Strain Contours for Case 1



260-37 Canyon Fuel Skyline [Figure 7(a) - (d)_Model 1.dwg Layout: Fig 7c]sm/rj(5-10-2010)

Figure 7c. Maximum Curvature Contours for Case 1

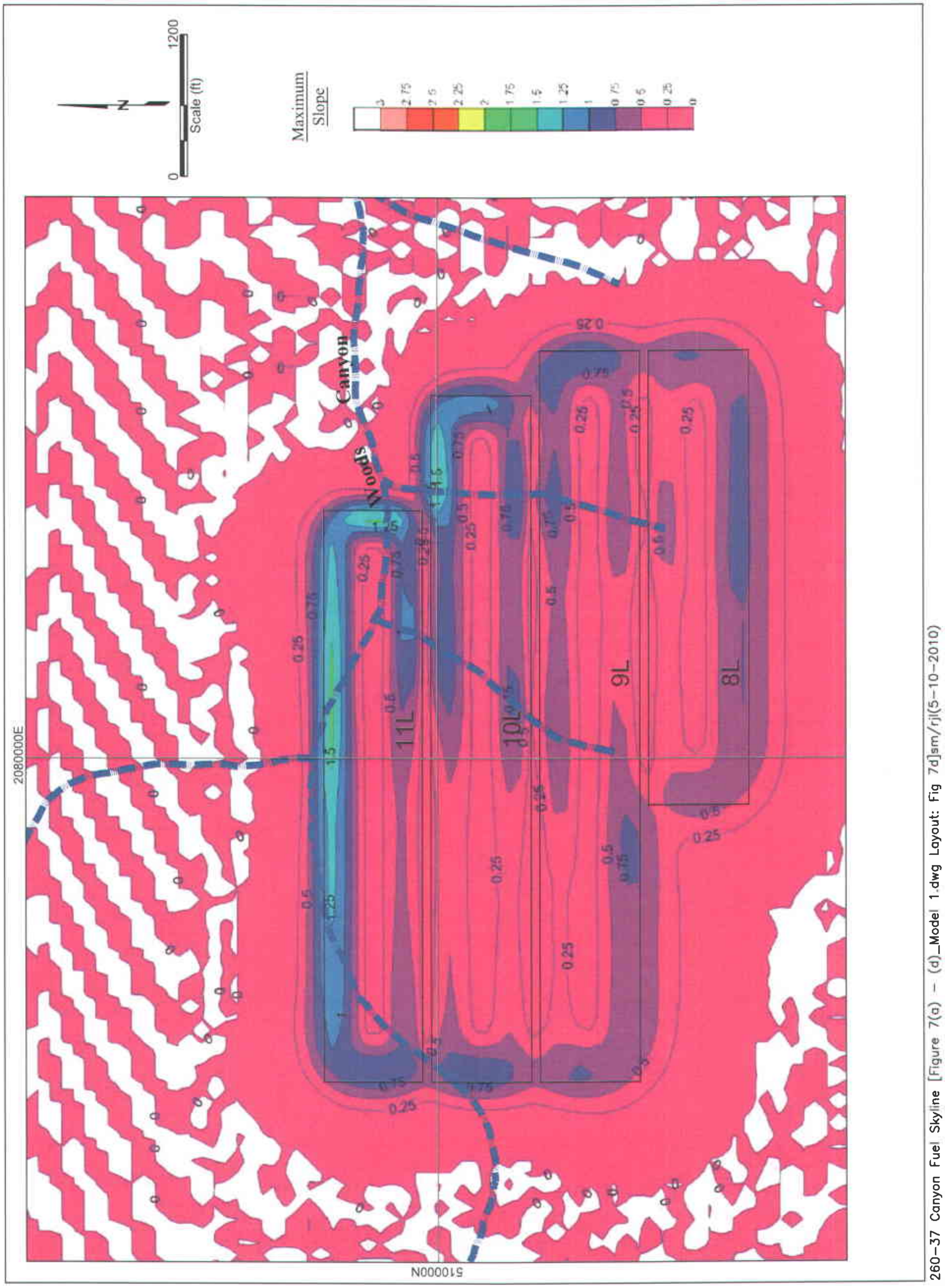


Figure 7d. Maximum Slope Contours for Case 1

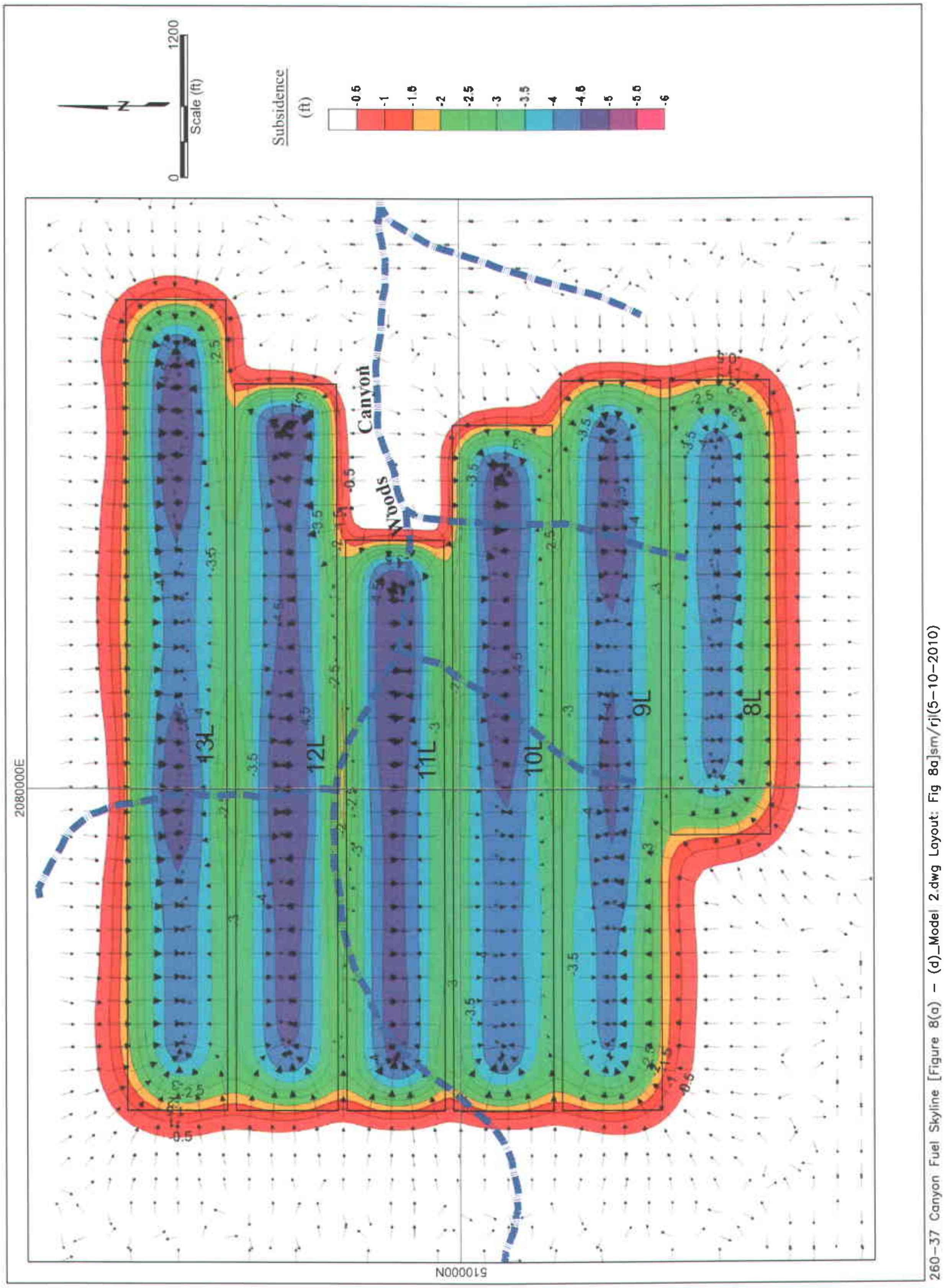


Figure 8a. Subsidence Contours for Case 2

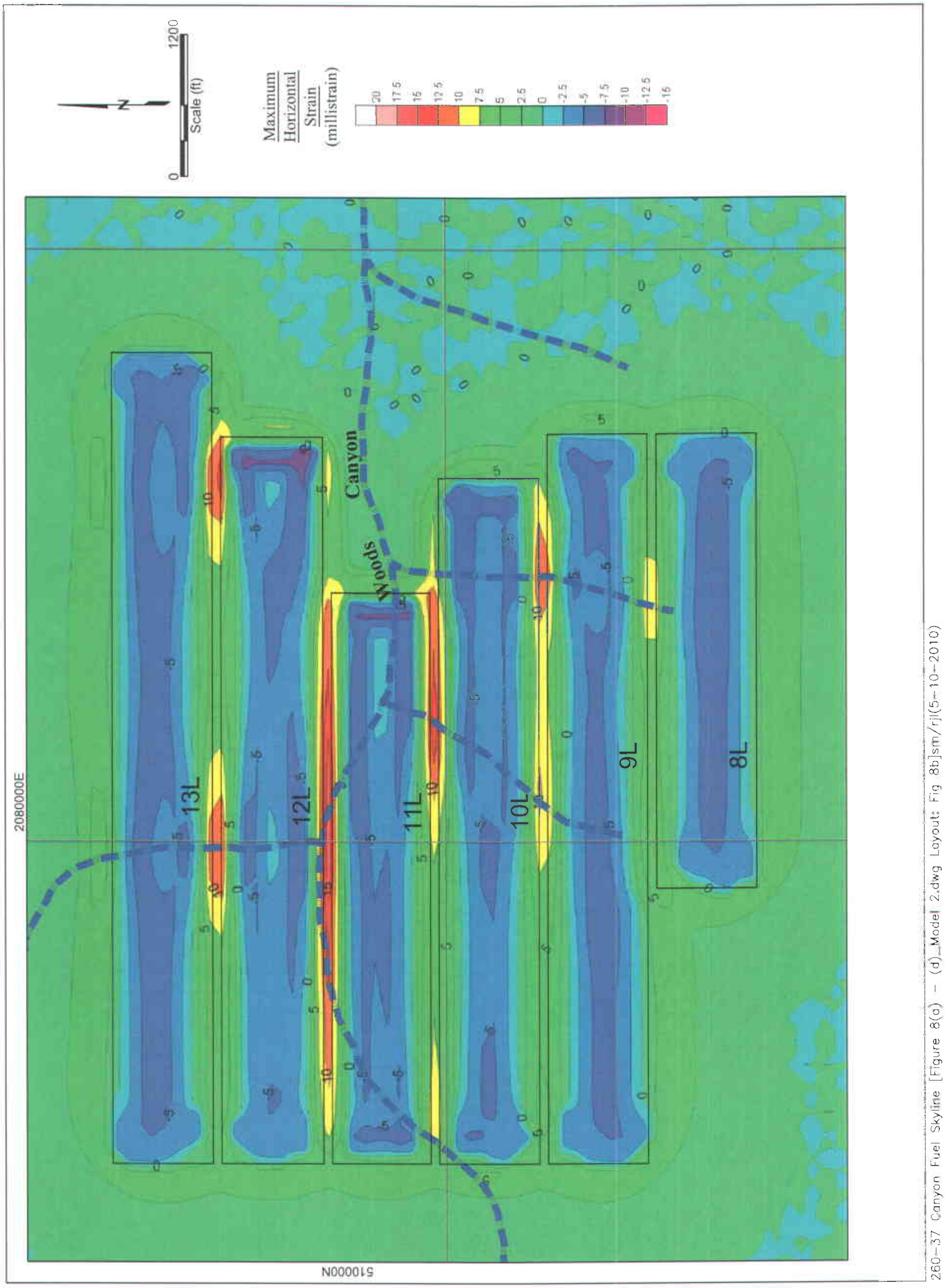


Figure 8b. Maximum Horizontal Strain Contours for Case 2

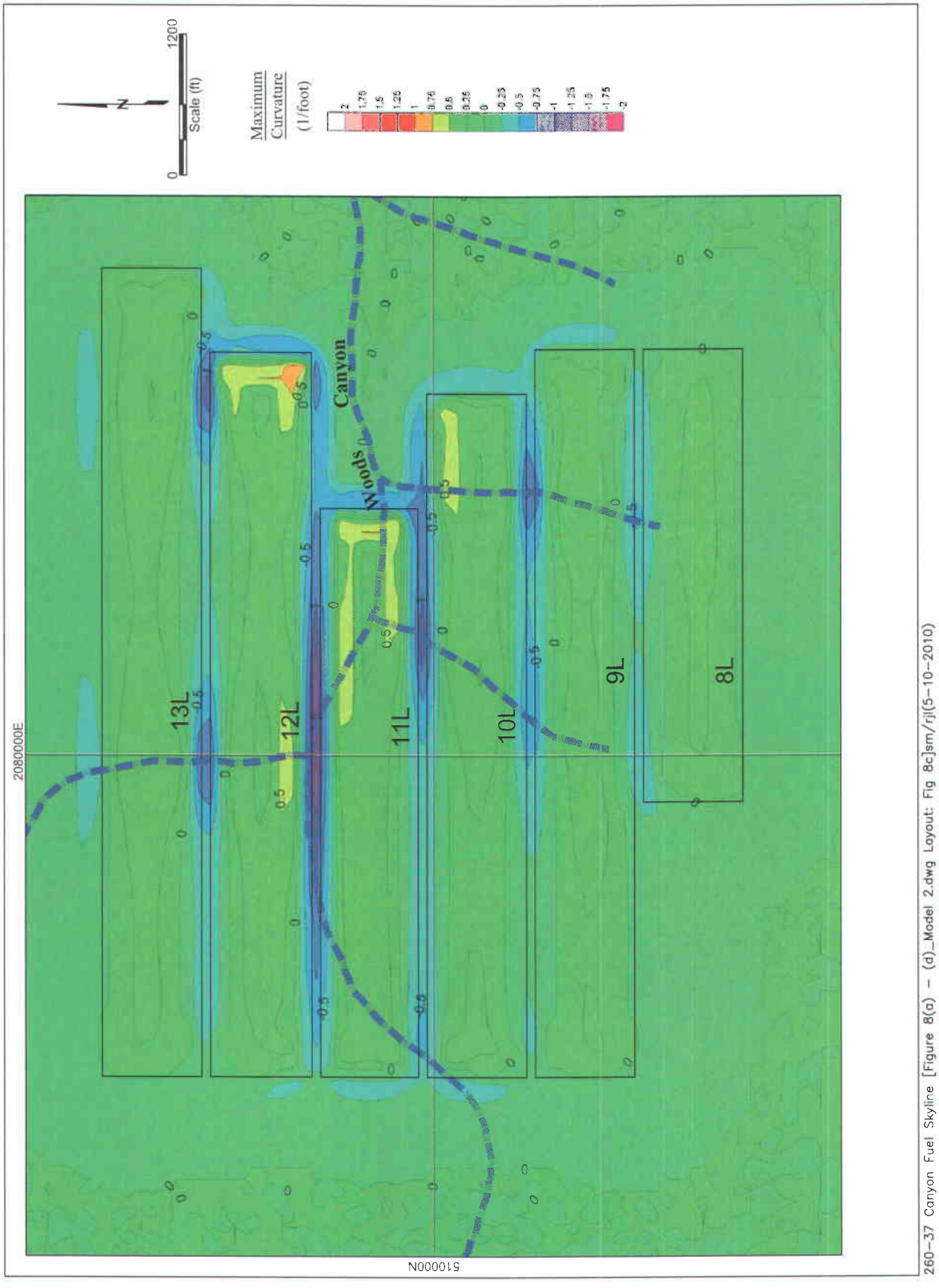
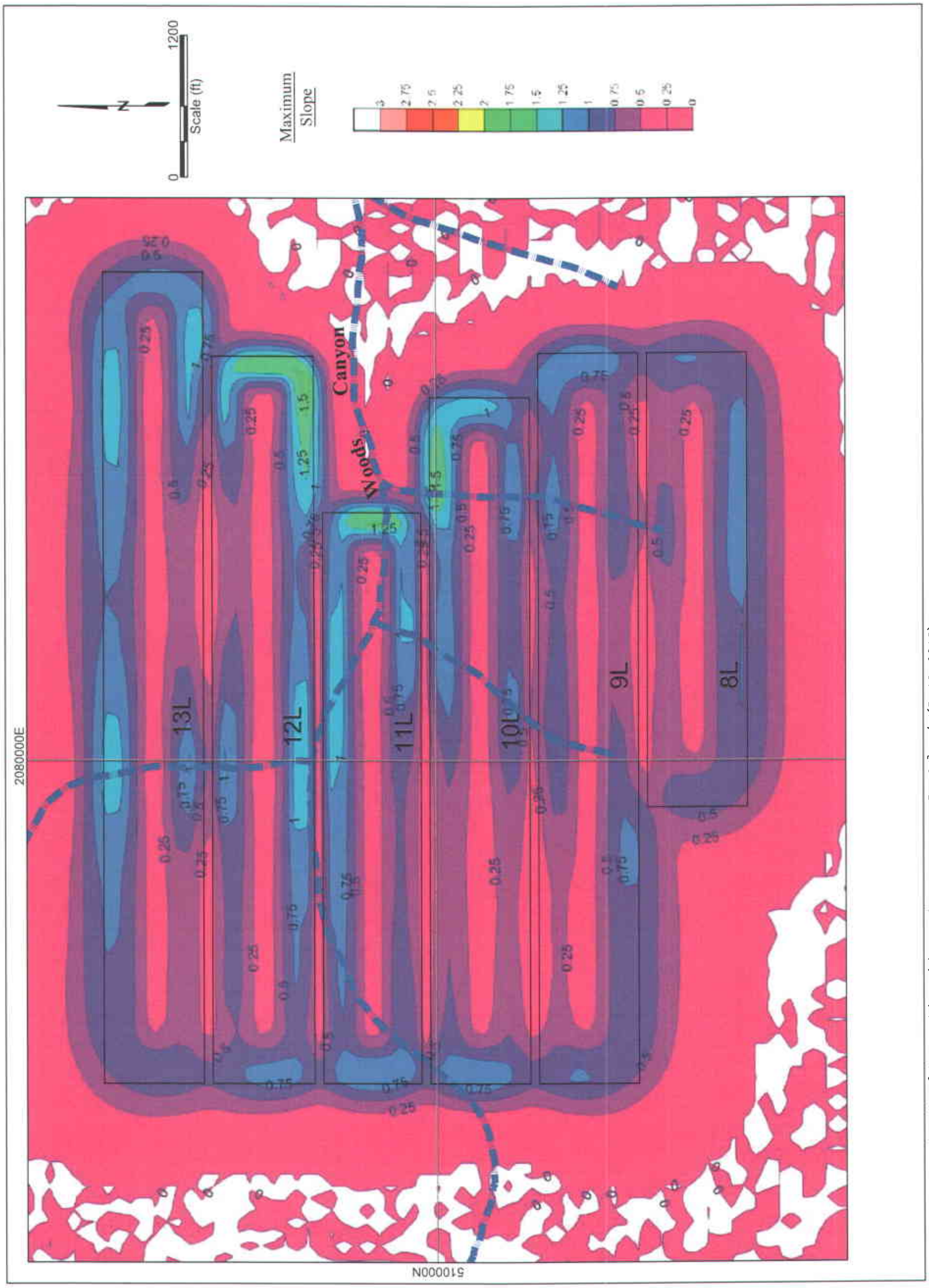


Figure 8c. Maximum Curvature Contours for Case 2



260-37 Canyon Fuel Skyline [Figure 8(a) - (d)_Model 2.dwg Layout: Fig 8d]sm/rjl(5-10-2010)

Figure 8d. Maximum Slope Contours for Case 2

edges of panels 10L, 11L and 12L, and also at the boundary shared by 11L and 12L, which may be attributed to the relatively lower cover depths and resulting higher subsidence in these areas.

The subsidence index plots for Case 3 are presented in Figures 9a–d. In this case, panel 11L has been mined beyond the currently projected stop line up to a cover depth of 400 ft. The deformation patterns are similar to Case 1. The maximum subsidence value is still less than 5 ft (Figure 9a); maximum compressive strain values (up to –10 millistrain) are observed at the eastern edge of 11L subsidence trough; the maximum values of tensile horizontal strain (15–17.5 millistrain) occur between the eastern ends of panels 10L and 11L (Figure 9b). Maximum curvature contours for Case 3 are presented in Figure 9c and maximum slope contours are presented in Figure 9d, with the eastern boundary of panel 11L specifically exhibiting steep slopes.

Figures 10a–d present the subsidence index plots for Case 4. In this case, panel 11L has been mined beyond the currently projected stop line up to a cover depth of 400 ft, and panels 12L and 13L have also been mined up to the same easting as panel 11L (albeit with a larger cover depth). The deformation patterns are similar to Case 2, only more expansive. The maximum subsidence is less than 5 ft (Figure 10a); the maximum values of compressive strain (up to –10 millistrain) are observed at the eastern edge of 11L; the largest tensile strains (15–17.5 millistrain) are at the inter-panel boundary of 11L and 12L, along the Woods Canyon, and also, further to the east. Maximum curvature contours for Case 4 are presented in Figure 10c and maximum slope contours are presented in Figure 10d, with the eastern boundary of panel 11L exhibiting steep slopes.

4.3 Impact of Subsidence on Woods Canyon

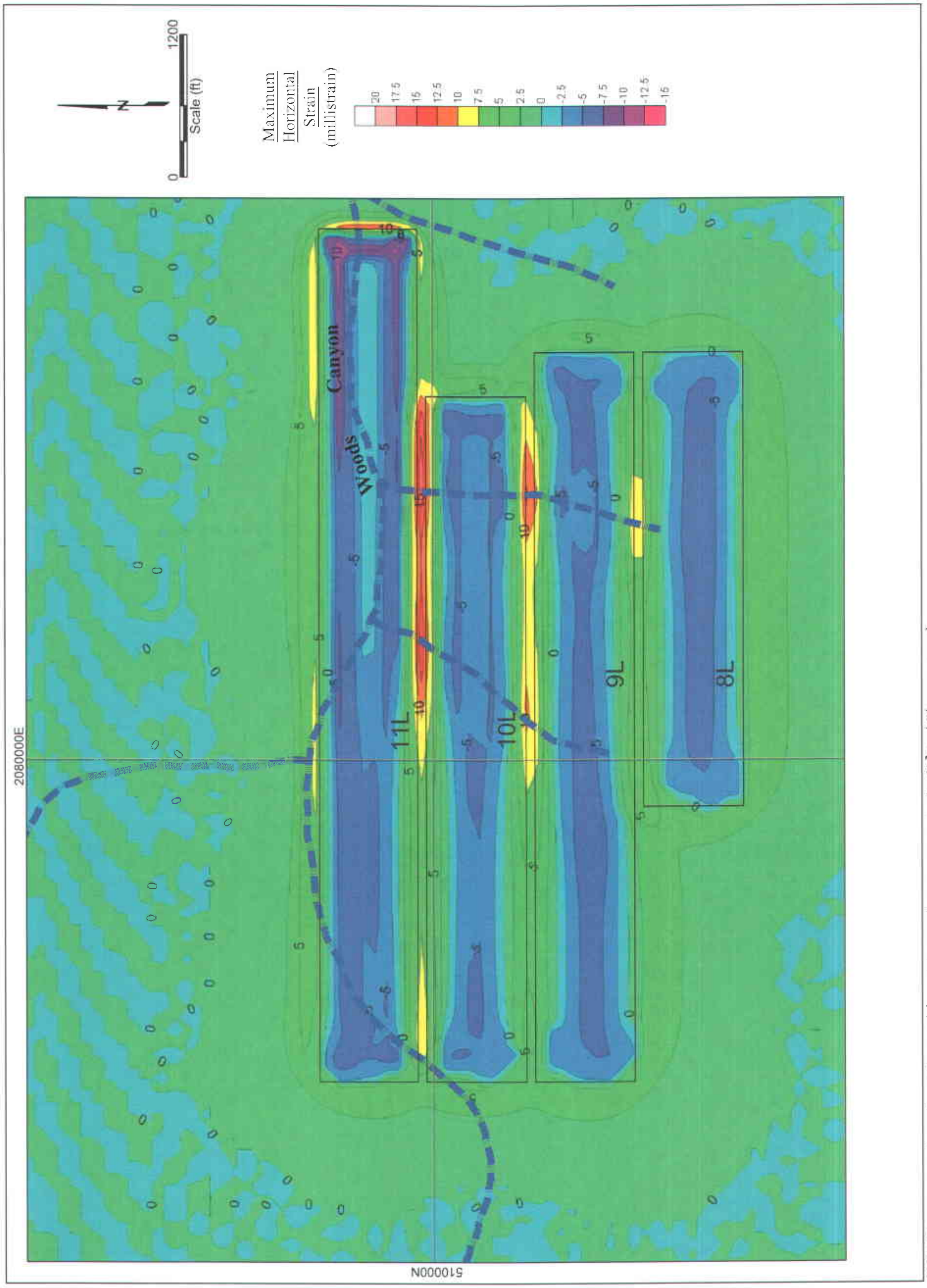
A longitudinal section along the flow path of the Woods Canyon drainage was taken and subsidence index contours plots were generated for all four prediction model runs. The indices were plotted along the entire length of the stream (from its origin point to its confluence point with Mud Creek on the east). The observed results are discussed below.

Figure 11a presents the subsidence experienced along the stream length in Cases 1 and 2, where panel 11L has been mined to a cover depth of 600 ft. The maximum subsidence observed is less than 5 ft. The extent of the subsidence profile is the same in both the cases, as the western boundary of panel 10L and eastern boundary of panel 11L are the same for both cases. It is only the subsidence values at the center that increase from Case 1 to Case 2. This is a consequence of panel 12L being mined in Case 2. Figure 11b presents subsidence for Cases 3 and 4, where panel 11L has been extended to terminate under 400 ft of cover to the east. The maximum subsidence is still less than 5 ft, with larger observed subsidence at the center for Case 4 due to mining of panel 12L. Overall, predicted subsidence for the Woods Canyon drainage is less than the subsidence predicted for both Burnout Canyon and James Canyon streams (as shown in Figures 3 and 4).

The maximum horizontal strains along the Woods Canyon stream for Cases 1 and 2 are plotted in Figure 12a. The tensile (positive) horizontal strains at both ends represent the zones where the Woods Canyon stream enters and exits the mining shadow zone. The tensile strains in the middle represent the stream's meander slightly to the north of the panel 11L boundary. The

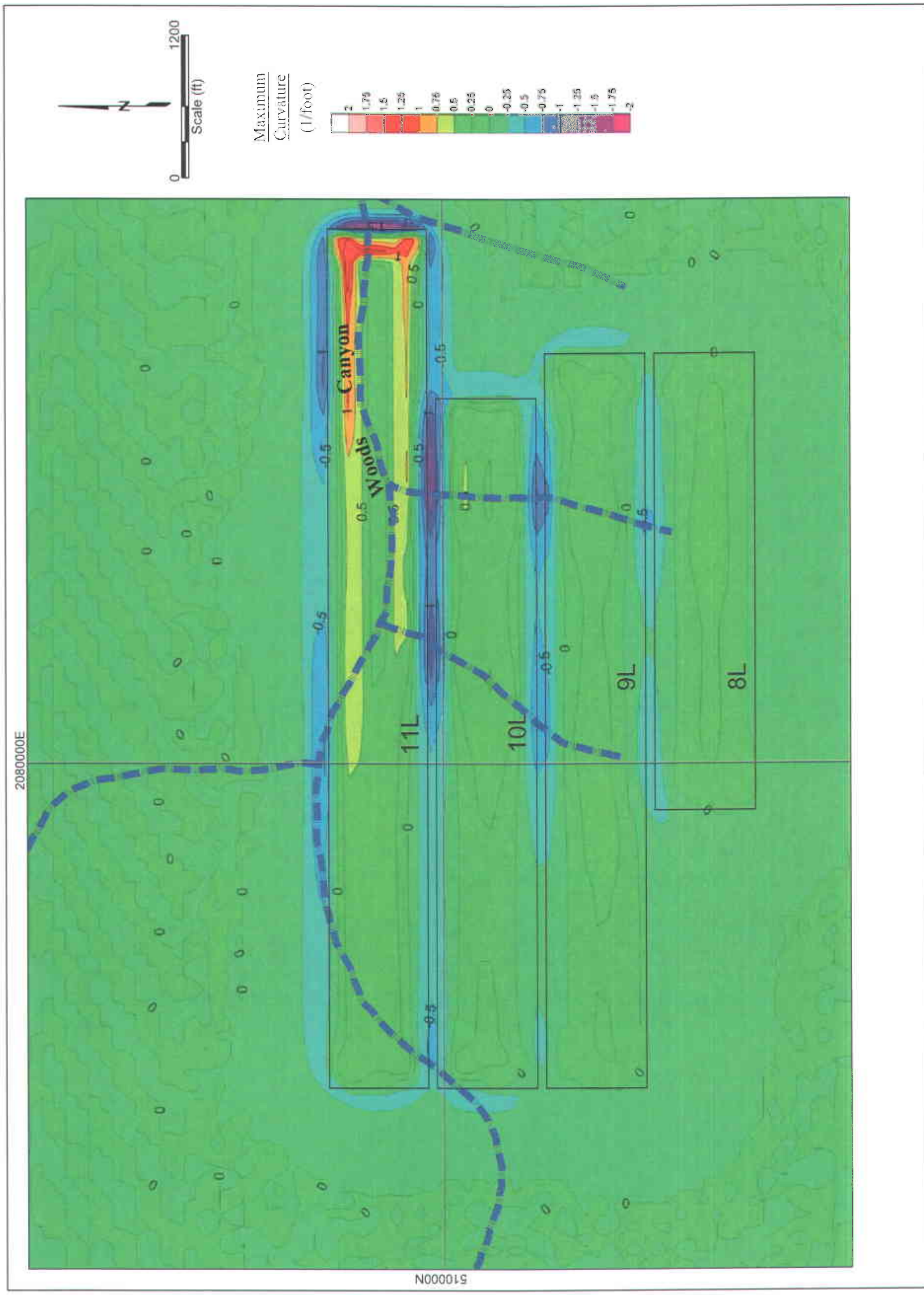
260-37 Canyon Fuel Skyline [Figure 9(a) – (d)_Model 3.dwg Layout: Fig 9a]sm/rjl(5-10-2010)

Figure 9a. Subsidence Contours for Case 3



260-37 Canyon Fuel Skyline [Figure 9(a) - (d)_Model 3.dwg Layout: Fig 9b]sm/rjl(5-10-2010)

Figure 9b. Maximum Horizontal Strain Contours for Case 3



260-37 Canyon Fuel Skyline [Figure 9(a) – (d)_Model 3.dwg Layout: Fig 9c]sm/rjl(5-10-2010)

Figure 9c. Maximum Curvature Contours for Case 3

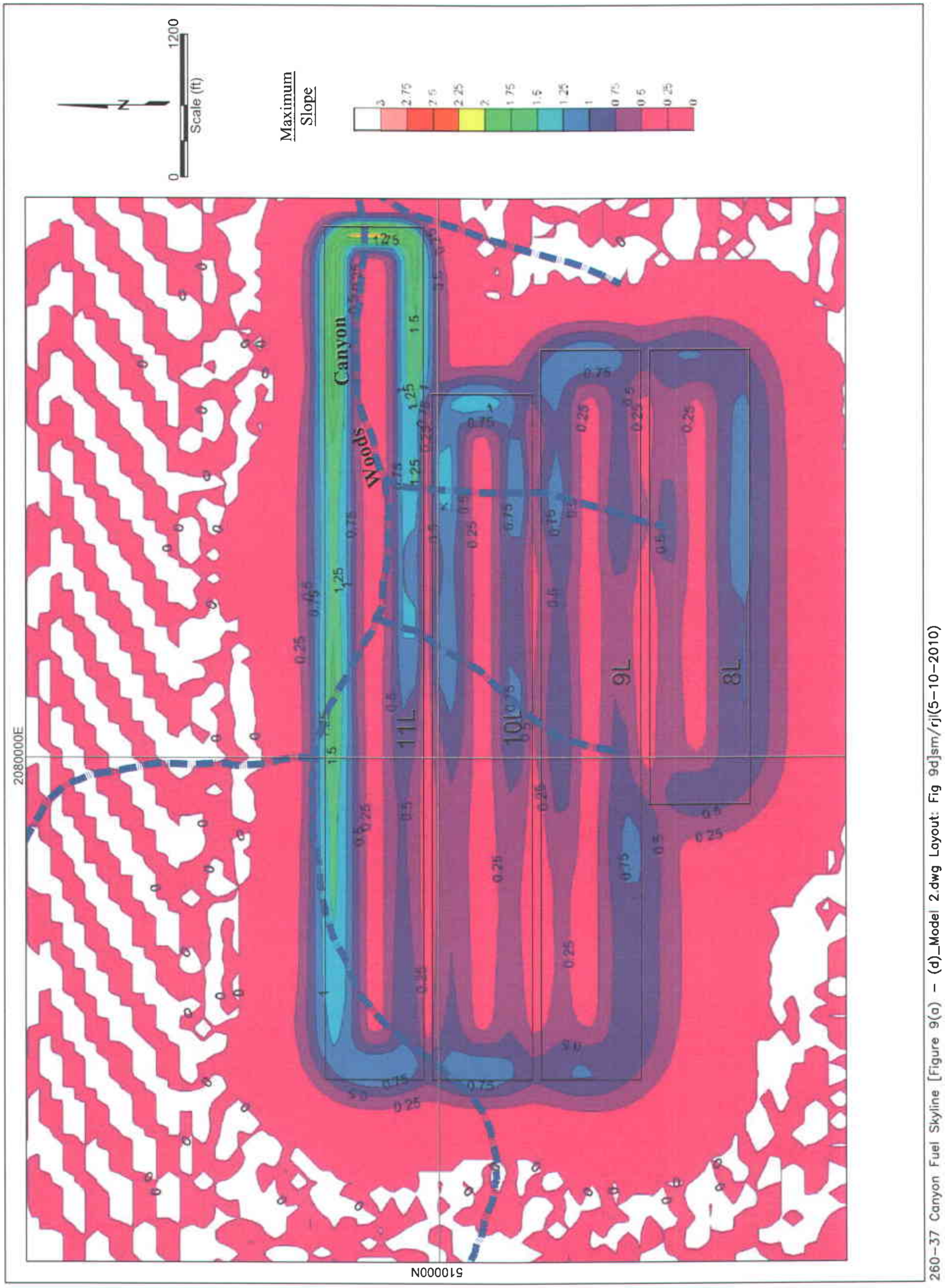
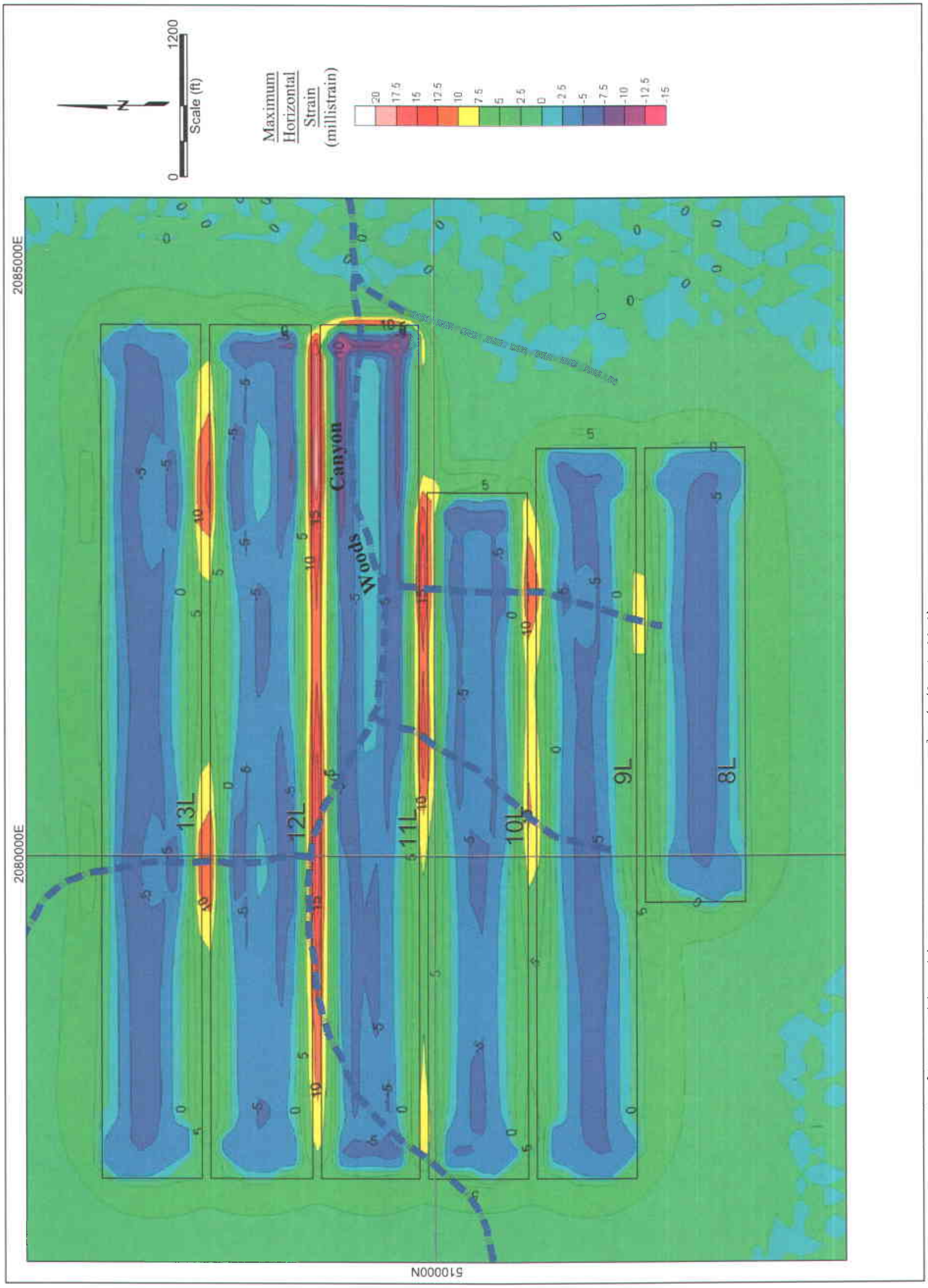


Figure 9d. Maximum Slope Contours for Case 3

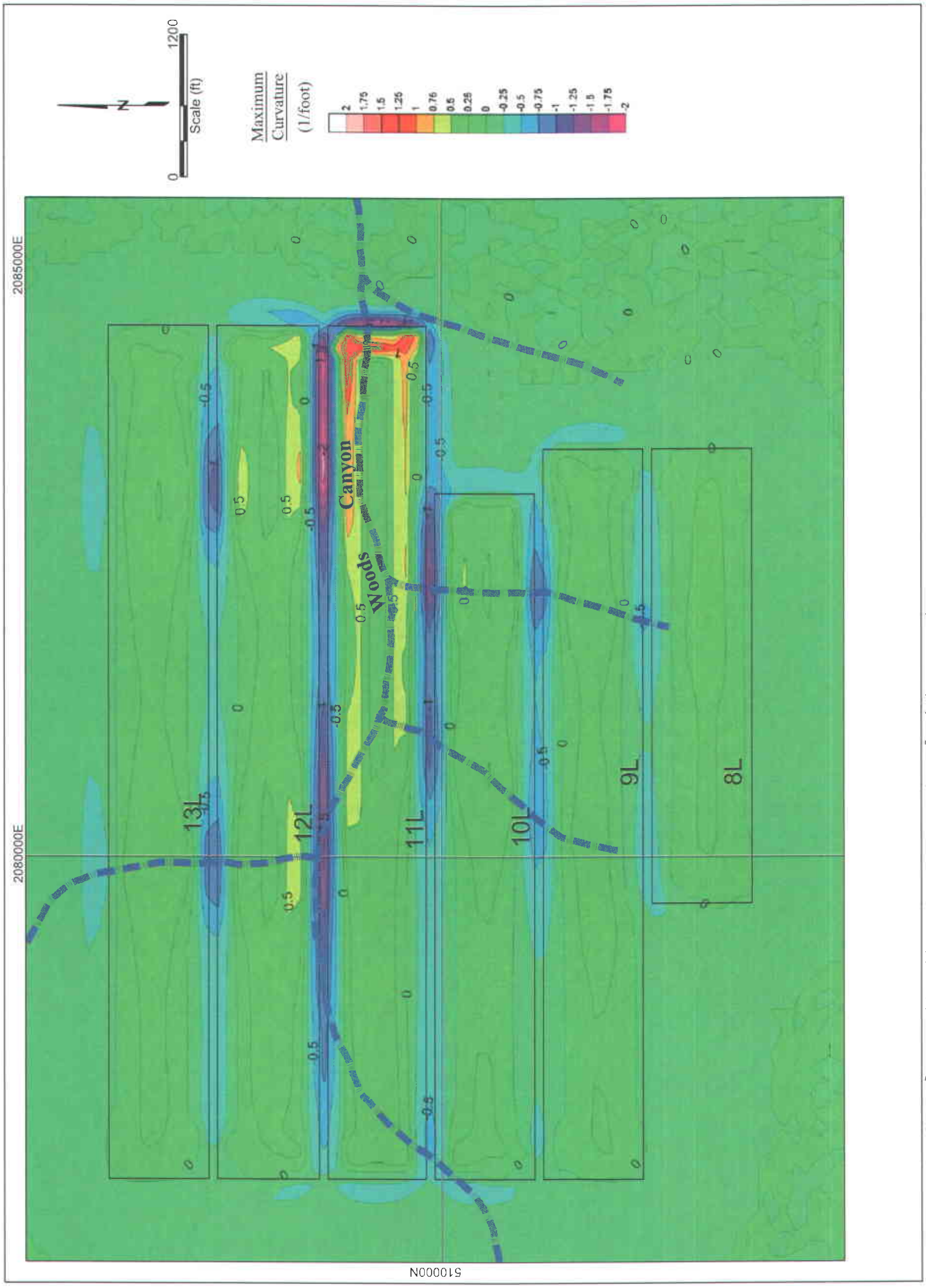
260-37 Canyon Fuel Skyline [Figure 10(a) - (d)_Model 4.dwg Layout: Fig 10a]sm/rjl(5-10-2010)

Figure 10a. Subsidence Contours for Case 4



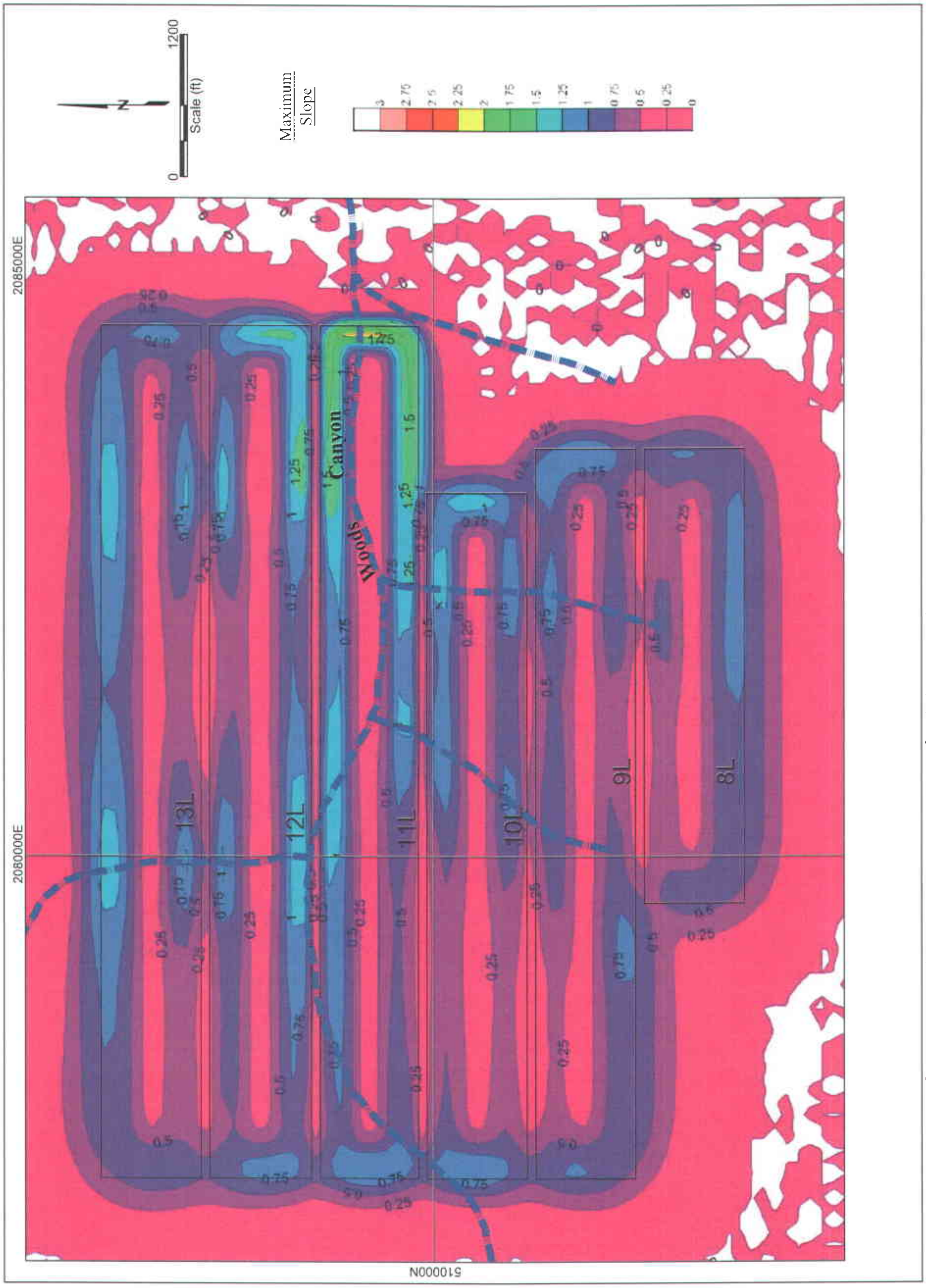
260-37 Canyon Fuel Skyline [Figure 10(a) – (d)_Model 4.dwg Layout: Fig 10b]sm/rj(5-10-2010)

Figure 10b. Maximum Horizontal Strain Contours for Case 4



260-37 Canyon Fuel Skyline [Figure 10(a) - (d)_Model 4.dwg Layout: Fig 10c]sm/rj(5-10-2010)

Figure 10c. Maximum Curvature Contours for Case 4



260-37 Canyon Fuel Skyline [Figure 10(a) – (d)_Model 4.dwg Layout: Fig 10d]sm/rjl(5-10-2010)

Figure 10d. Maximum Slope Contours for Case 4

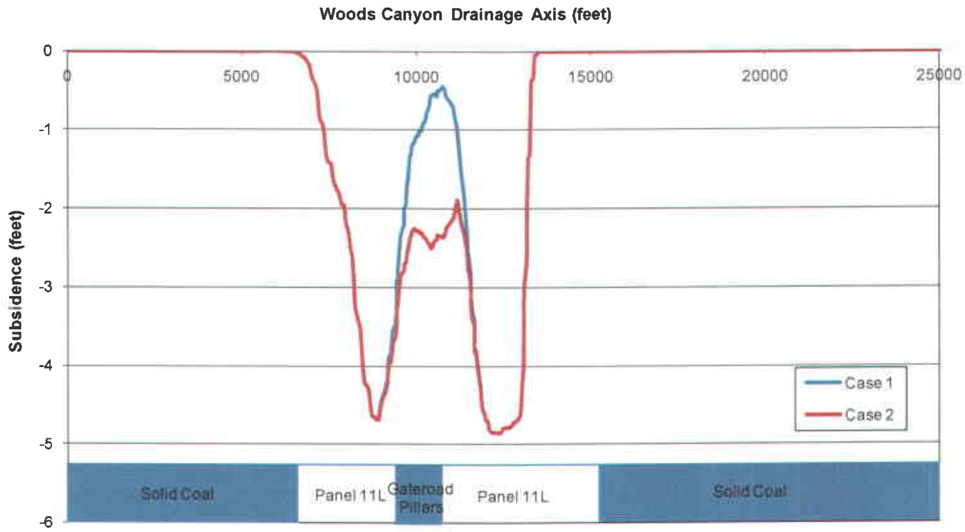


Figure 11a. Subsidence along Axis of Woods Canyon, Case 1 and Case 2

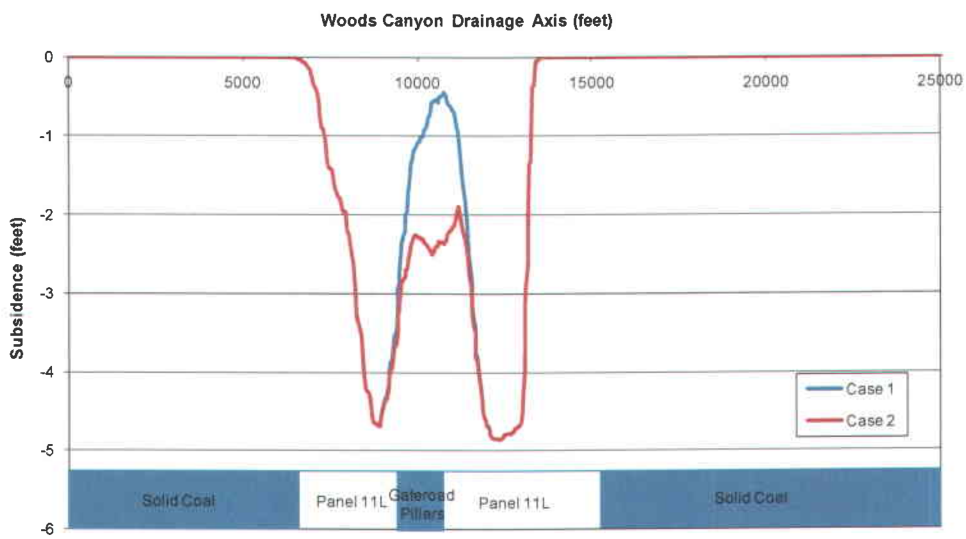


Figure 11b. Subsidence along Axis of Woods Canyon, Case 3 and Case 4

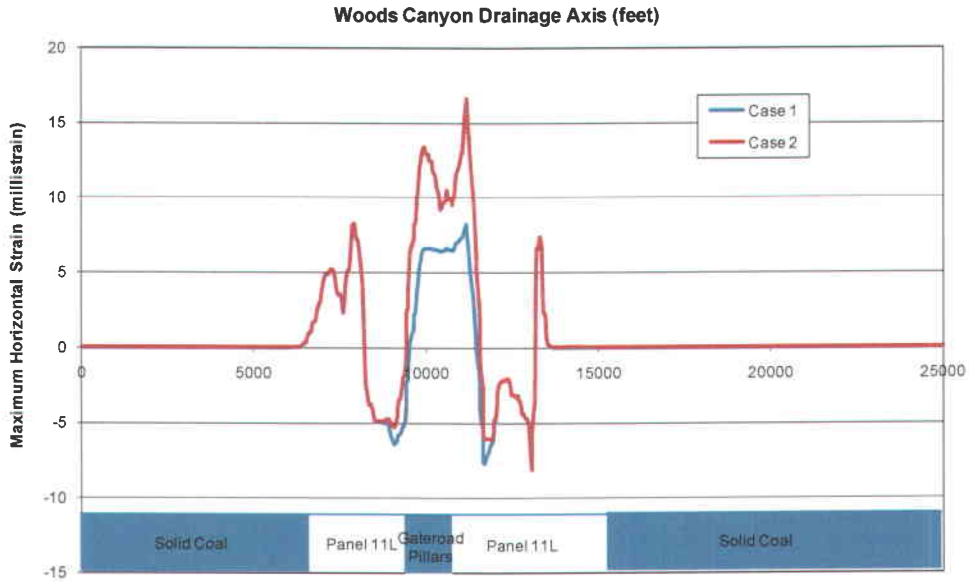


Figure 12a. Maximum Horizontal Strain along Axis of Woods Canyon, Case 1 and Case 2

highest value of tensile strain in this segment increases from 6 millistrain to 16 millistrain Similar horizontal strain observations are made in Cases 3 and 4, over the stream segment that exists between panels 11L and 12L (Figure 12b). This indicates that superposed strains from both the panels lead to a larger value of tensile strain experienced by the stream. The tensile strain value at the eastern edge is greater in Cases 3 and 4 than in Cases 1 and 2. This is explained by the decreased depth of cover for Cases 3 and 4. Overall, the predicted maximum horizontal tensile strains for Woods Canyon are less than those predicted for the Burnout Canyon drainage and comparable to those predicted for James Canyon.

Maximum curvature along the Woods Canyon stream for all four mining scenarios is presented in Figures 13a–b. Curvature values are increased in the center for Cases 2 and 4, a consequence of larger subsidence due to mining of the adjacent 12L panel to the north. The sudden spike in curvature values in Cases 3 and 4 may be explained by low cover depth (400 ft) and increased subsidence in the area. The maximum curvature values are comparable to those observed in the Burnout and James Canyon. The maximum slope plots along the Woods Canyon stream for all four mining scenarios are presented in Figures 14a–b. The slope trends are similar for all four cases, except for the fact that the extent of the profile is longer to the east for Cases 3 and 4, owing to the longer length of panel 11L. Also, the slope is steepest at the eastern edge of panel 11L, where the Woods Canyon stream exits the mining zone. This is a consequence of low depth of cover and relatively large subsidence (up to 5 ft) in this segment of the stream.

Review of the analysis results of the four predictive models with four different longwall layouts indicates that the predicted subsidence indices of the Woods Canyon stream are lesser in magnitude compared to the Burnout Canyon stream and similar to, if not less than, the James Canyon stream. Also, the average gradient of the Woods Canyon over the extraction area (approximately 5.71%) is larger than that of the Burnout Canyon over the 11L and 12LA panels (approximately 4.12%). A comparison of average gradients along the analyzed segments for

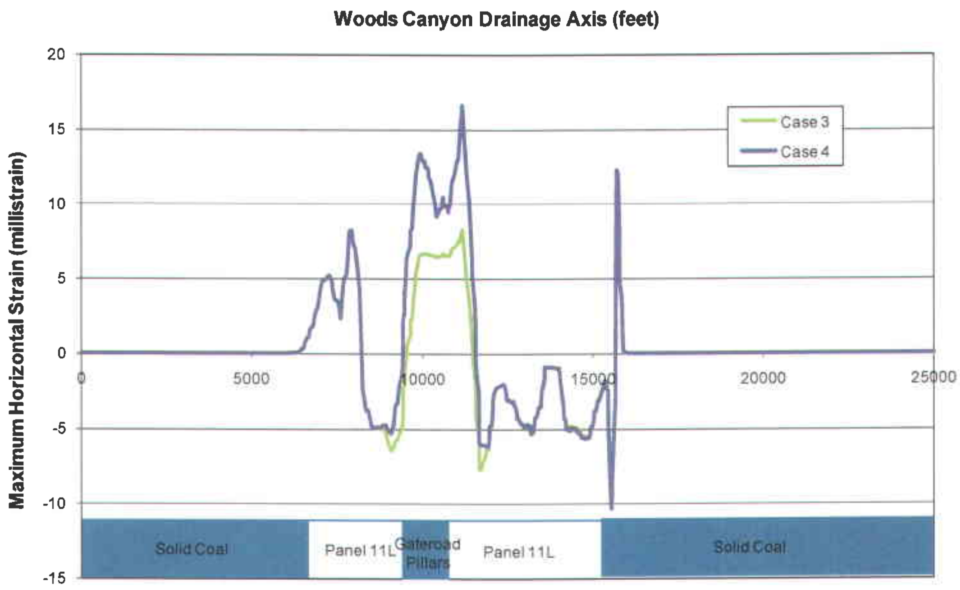


Figure 12b. Maximum Horizontal Strain along Axis of Woods Canyon, Case 3 and Case 4

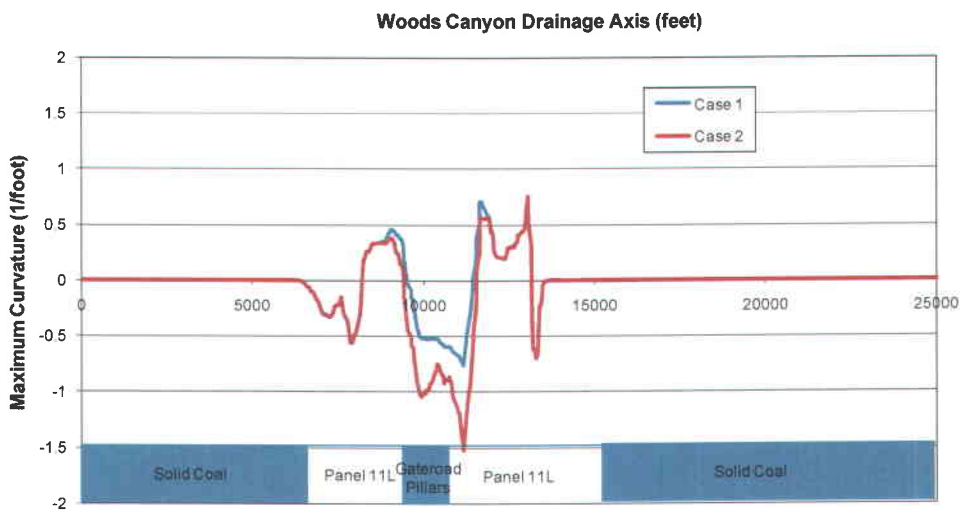


Figure 13a. Maximum Curvature along Axis of Woods Canyon, Case 1 and Case 2

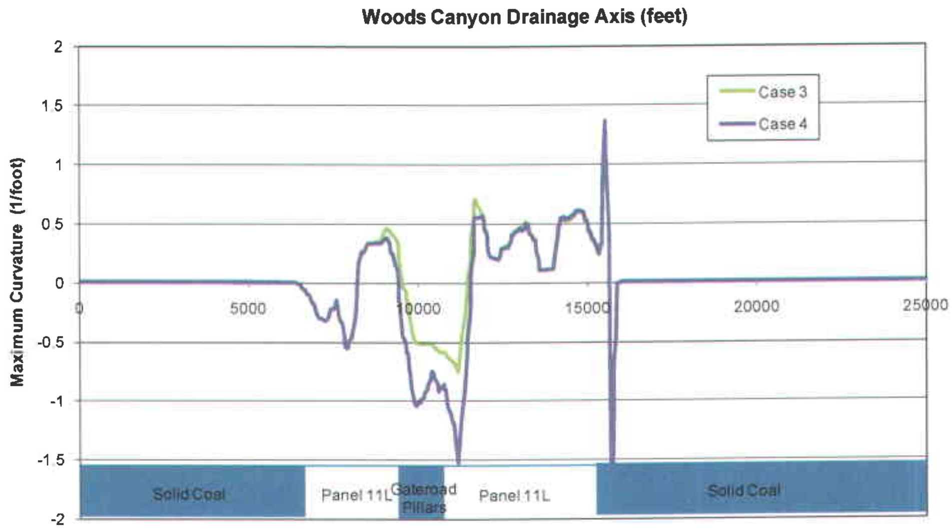


Figure 13b. Maximum Curvature along Axis of Woods Canyon, Case 3 and Case 4

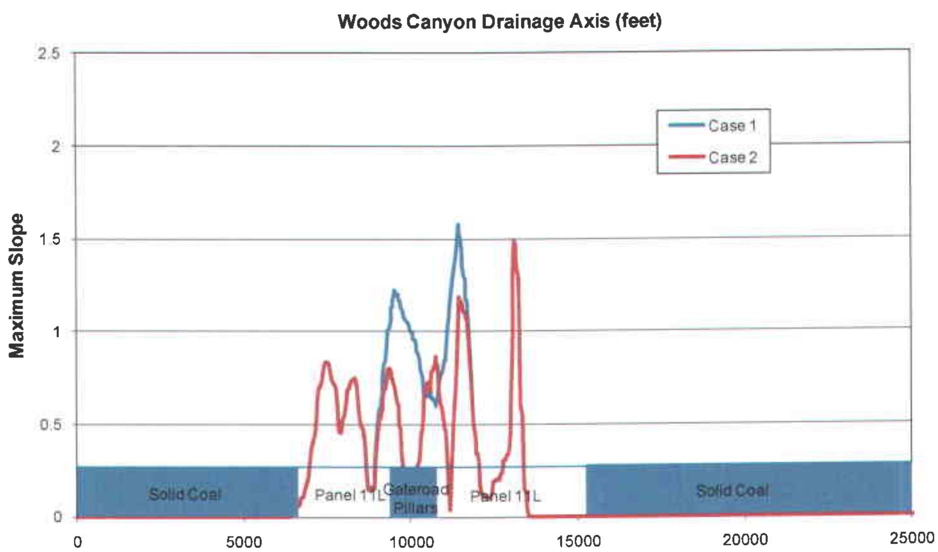


Figure 14a. Maximum Slope along Axis of Woods Canyon, Case 1 and Case 2

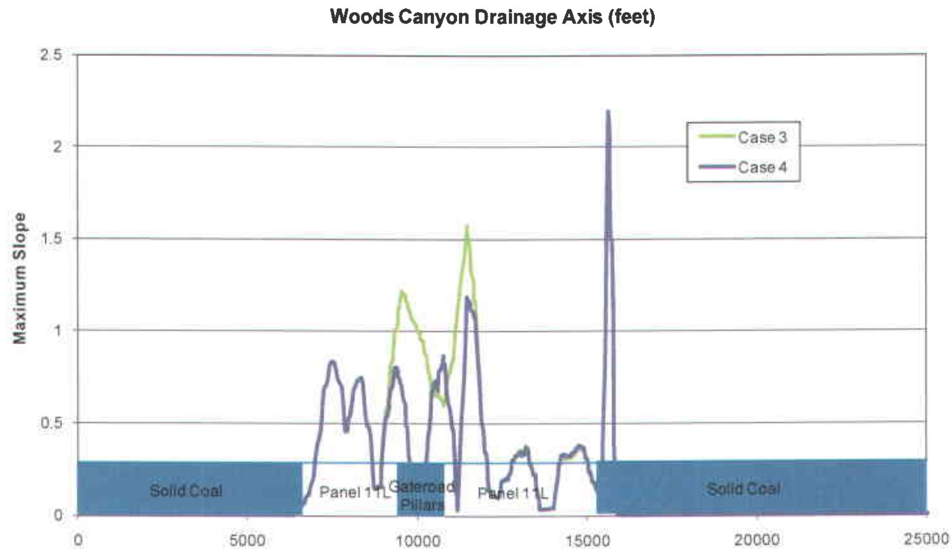


Figure 14b. Maximum Slope along Axis of Woods Canyon, Case 3 and Case 4

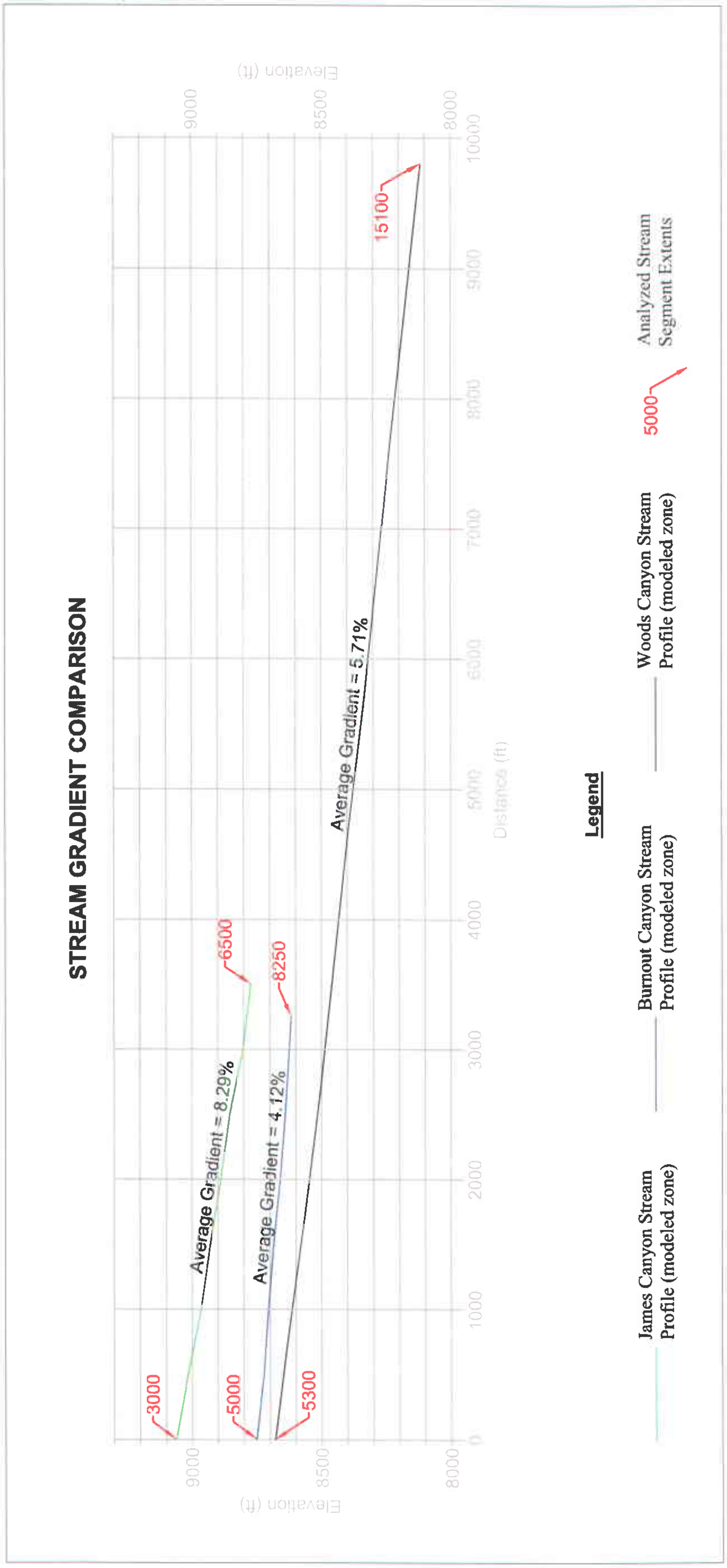
Burnout and Woods Canyon is presented in Figure 15. Since a steeper gradient means that any horizontal strain experienced will be spread along a longer stream path, it may dampen some of the direct impacts of tensile strains resulting from subsidence on the Woods Canyon.

4.4 Impact of Longwall Pillar Yielding on Woods Canyon Subsidence

The numerical models simulating mining-induced subsidence in the Burnout Canyon and Woods Canyon area were developed assuming that inter-panel gate road pillars do not yield. This provides worst-case estimates of horizontal strain, slope and curvature. The assumption of non-yielding pillars arose from the application of the Burnout Canyon calibration effort to the Woods Canyon models. That is, because the Burnout Canyon gate road pillars were non-yielding, as reflected in the measured subsidence data, the same assumption was applied to the Woods Canyon gate road pillars. However, the gate road pillars planned for Woods Canyon are designed to yield. Therefore, further analysis was performed to quantify the impact of pillar yielding on surface subsidence in Woods Canyon.

Prior to simulating the effect of gate road pillar yielding on surface subsidence, an estimate of the degree of yielding as a function of cover depth was developed.

The Woods Canyon panel layout in Case 2 was selected to analyze gate road pillar yielding, using the stress analysis modeling code LaModel. Case 2 was analyzed instead of Case 4, as programming limitations of LaModel could not accommodate the model dimensions of the latter. LaModel is a nonlinear, boundary-element, displacement-discontinuity computer code for estimating stress, displacement, and yielding in tabular deposits (Heasley and Salamon 1996). This tool has the ability to simulate both linear and nonlinear mechanical (stress-strain) behaviors of materials. It performs an iterative procedure to solve a set of



260-37 Canyon Fuel Skyline [Figure 15.dwg Layout: Fig 15]sm/deh(5-10-2010)

Figure 15. Comparative Plot of Burnout and Woods Canyon Stream Gradients

equations representing the stress-strain state of each element in a grid portraying the mine geometry, until steady-state equilibrium is reached. Following a Mine Safety and Health Administration (MSHA) recommended confined core approach to pillar strength (Karabin and Evanto 1994), element properties are arranged so that the weakest elements are adjacent to the mine opening, with element strengths increasing into the solid unmined materials. Strain-softening elements with increasing peak and residual strengths are employed to approximate elastic-plastic behaviors observed in pillars and to provide close agreement with empirical pillar design methods. The developed model used square elements and eight levels of increasing element strength into the solid coal. Each band of strength was one element wide. In order to closely approximate the geometry of the as-mined gate road pillars, 9-ft elements were selected. In the absence of data on coal, overburden, floor and gob characteristics, parameters used in a previous AAI report (AAI 2005) on barrier pillar analysis at Skyline were used (Table 1). Actual cover depth over the modeled area was applied.

Table 1. Strata Characteristics used in LaModel Simulation

Young's Modulus of roof and floor (psi)	1,600,000
Young's Modulus of coal seam (psi)	400,000
Poisson's Ratio of overburden	0.25
Poisson's Ratio of coal	0.35
Peak strength of yield pillars (psi)	3,000
Residual strength of yield pillars (psi)	700
Young's Modulus of gob (psi)	67,000

The LaModel simulation results for Case 2 are presented in Figure 16. The blue colors indicate elastic behavior, orange indicates the onset of yielding, and red indicates complete yielding. It is evident from the results that the inter-panel gate road pillars in the Woods Canyon mining area will most likely yield completely over time, irrespective of the range of cover depth over the area. The yielding behavior of gate road pillars is anticipated to be similar between Case 2 and Case 4.

Since Case 4 represents an extraction scenario with maximum extraction, and is associated with the largest modeled values of subsidence and horizontal strain, this layout was modified to develop models for the evaluation of yielding. This modified yield pillar layout is referred to as Case 4a. The SDPS model for Case 4 was modified by merging the extracted areas together (removing solid gate road pillars between panels), resulting in the geometry for Case 4a shown in Figure 17. The values of maximum subsidence factor, edge offset and influence angle used in Cases 1 through 4 were retained for the Case 4a model.

The subsidence index plots for Case 4a are presented in Figures 18a–d. In this case, panel 11L has been mined beyond the currently projected stop line up to a cover depth of 400 ft, and panels 12L and 13L have also been mined up to the same easting as panel 11L. In addition, all the gate road pillars have completely yielded. The maximum subsidence value of 4.9 ft is observed across most of the subsidence basin (Figure 18a). The maximum compressive strain values (–10 millistrain) and the maximum tensile strain values (12 millistrain) occur towards the

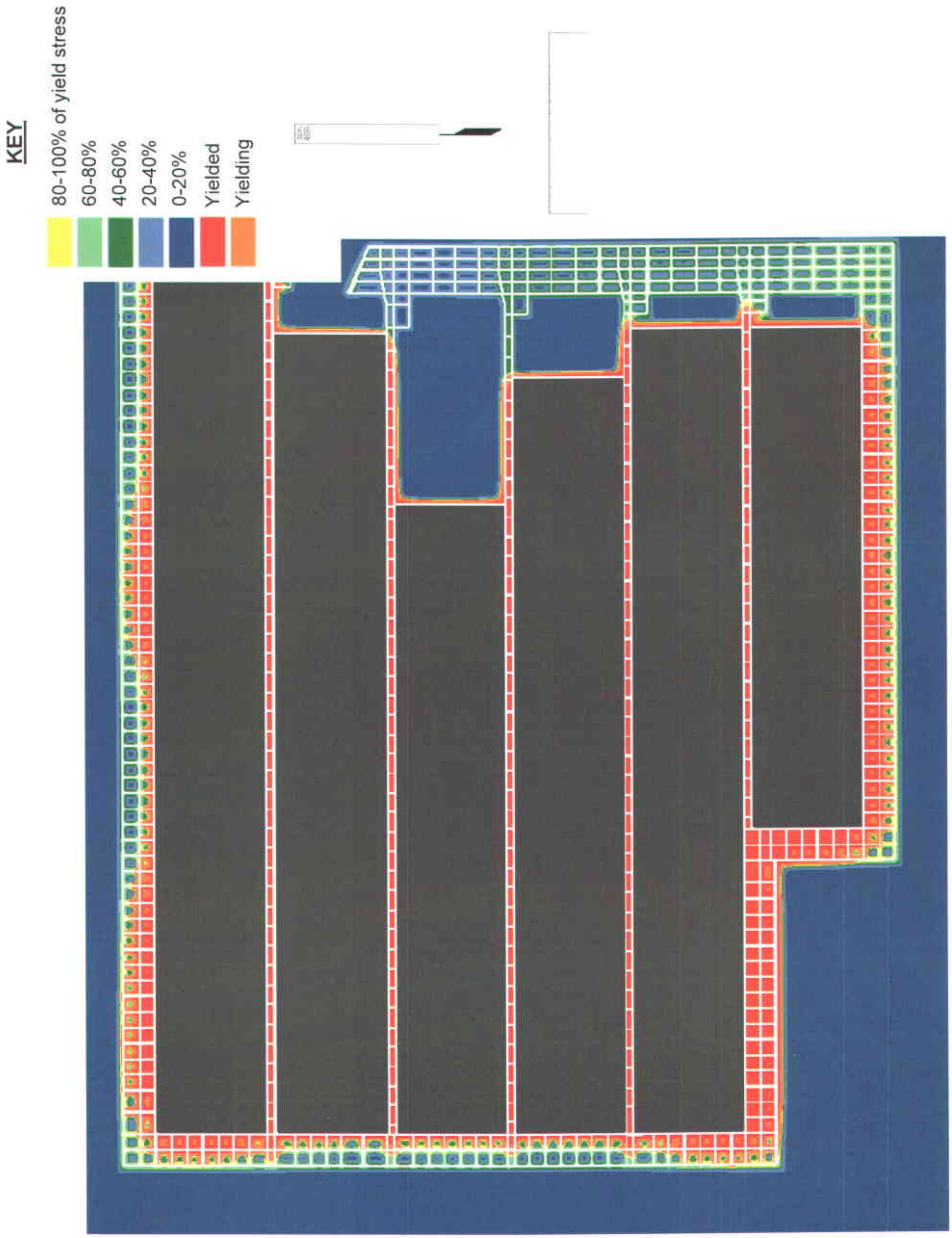
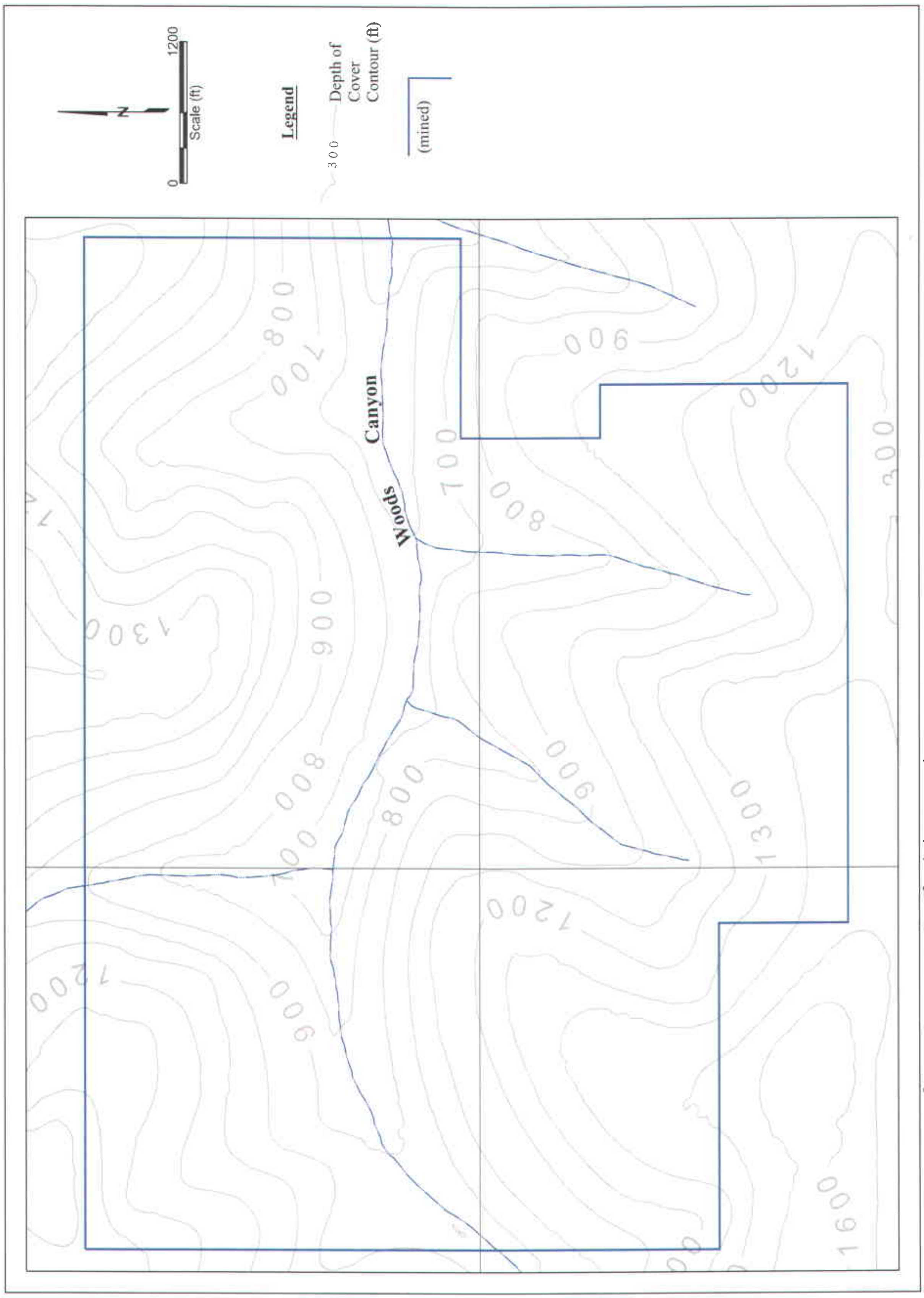
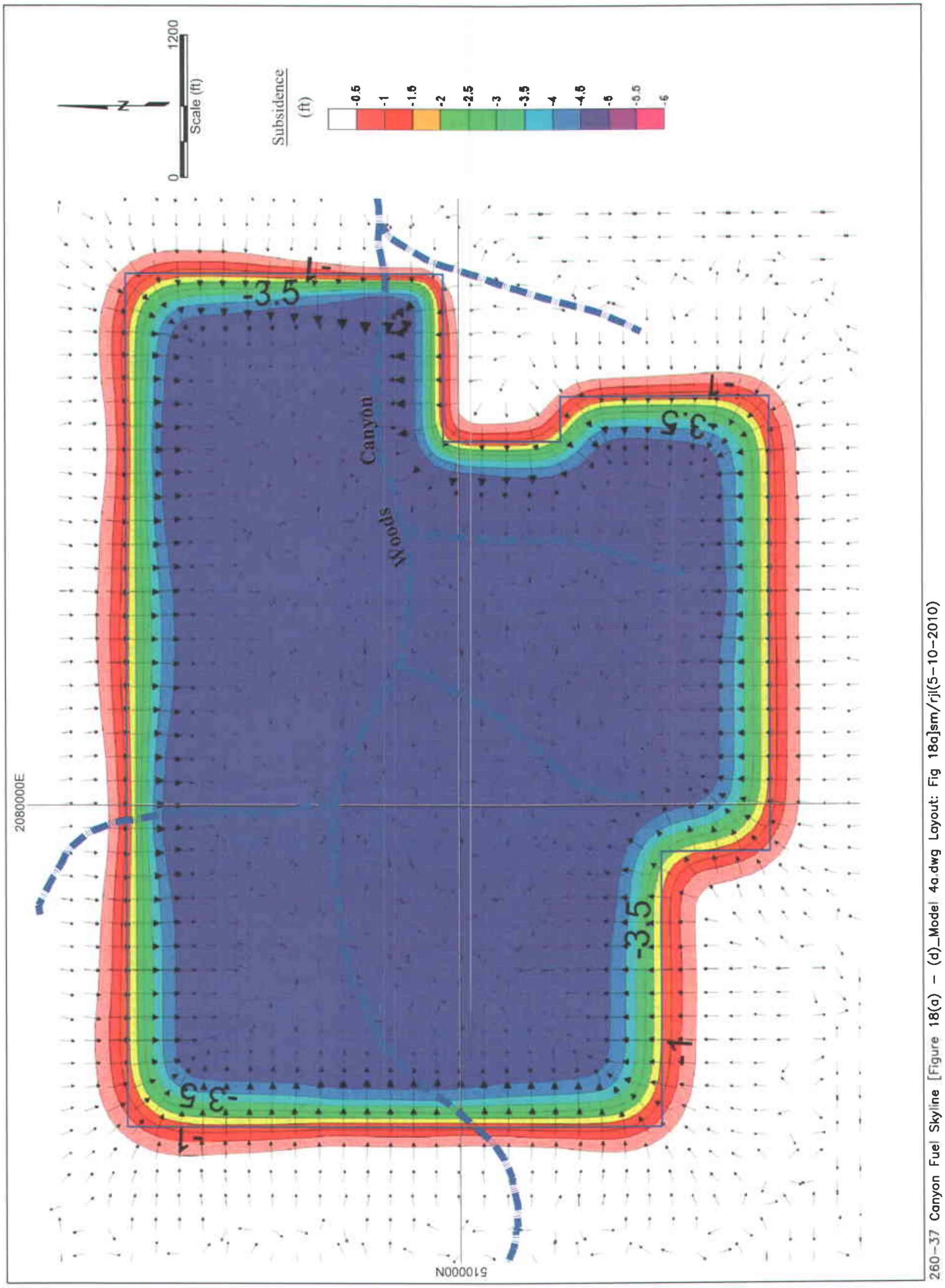


Figure 16. LaModel Analysis Results for Case 2

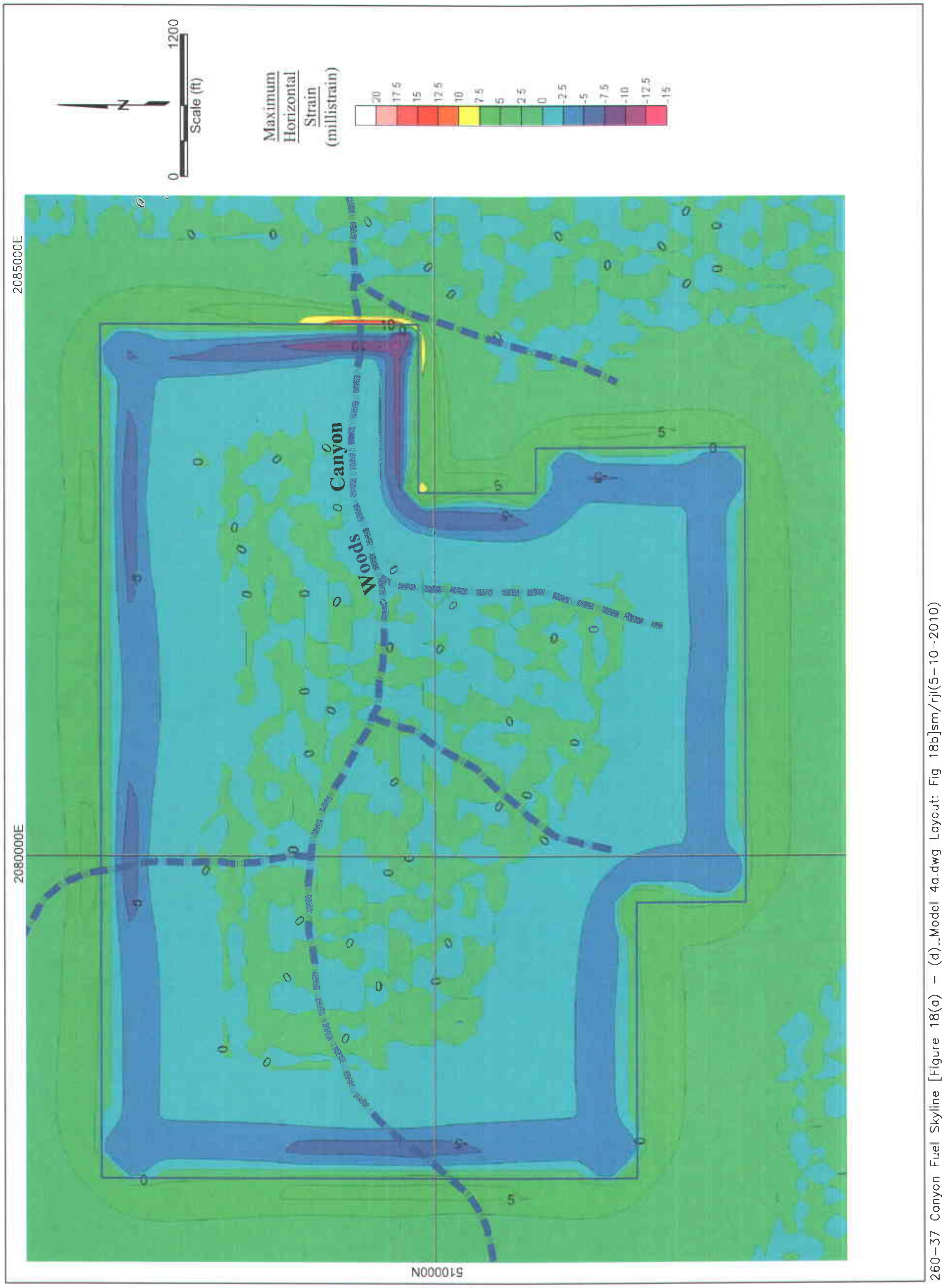


260–37 Canyon Fuel Skyline [Figure 17.dwg Layout: Fig 17]sm/rjl(5–10–2010)

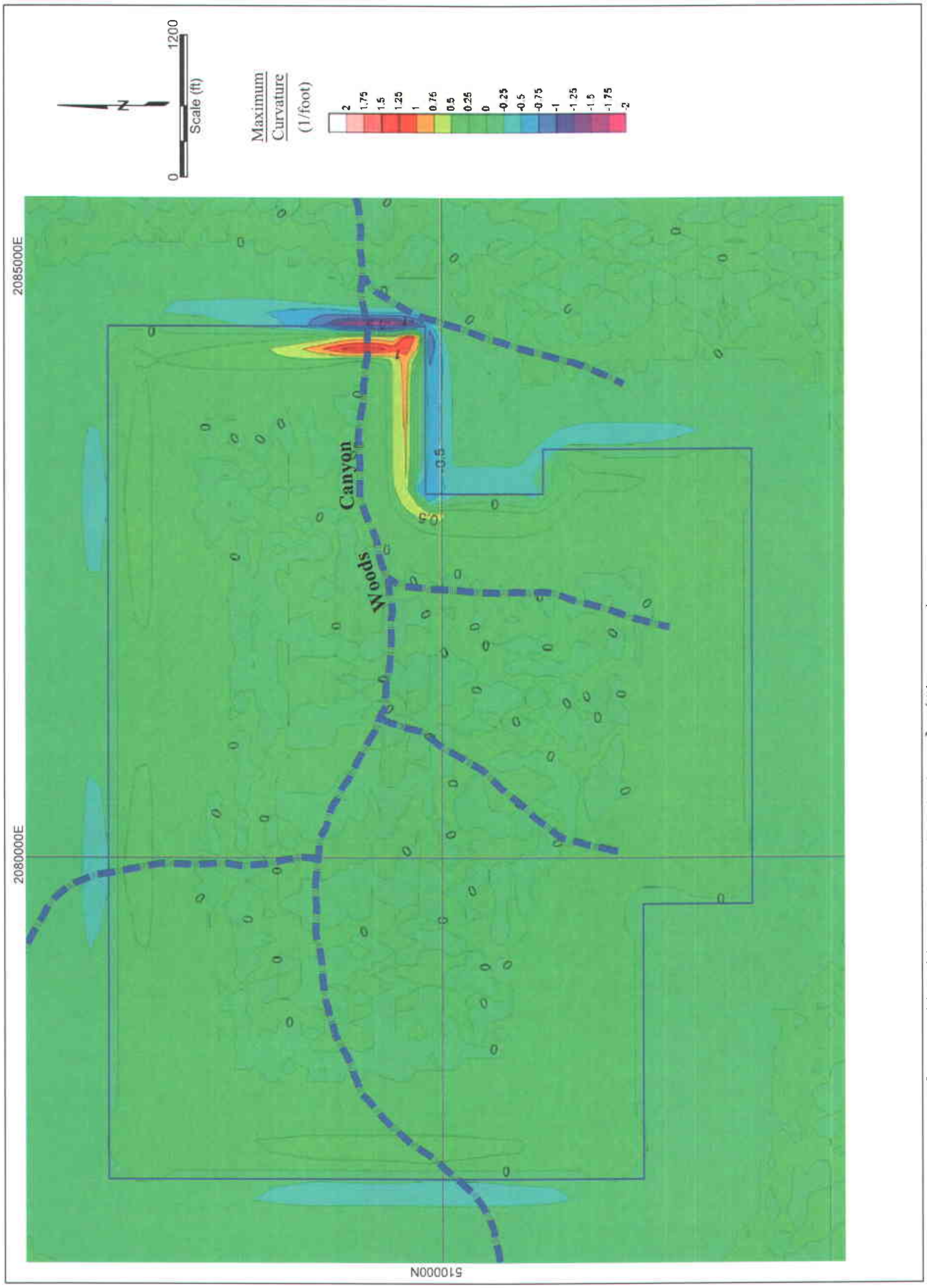
Figure 17. Longwall Mining Layout for Numerical Analysis; Case 4a



18a. Subsidence Contours for Case 4a

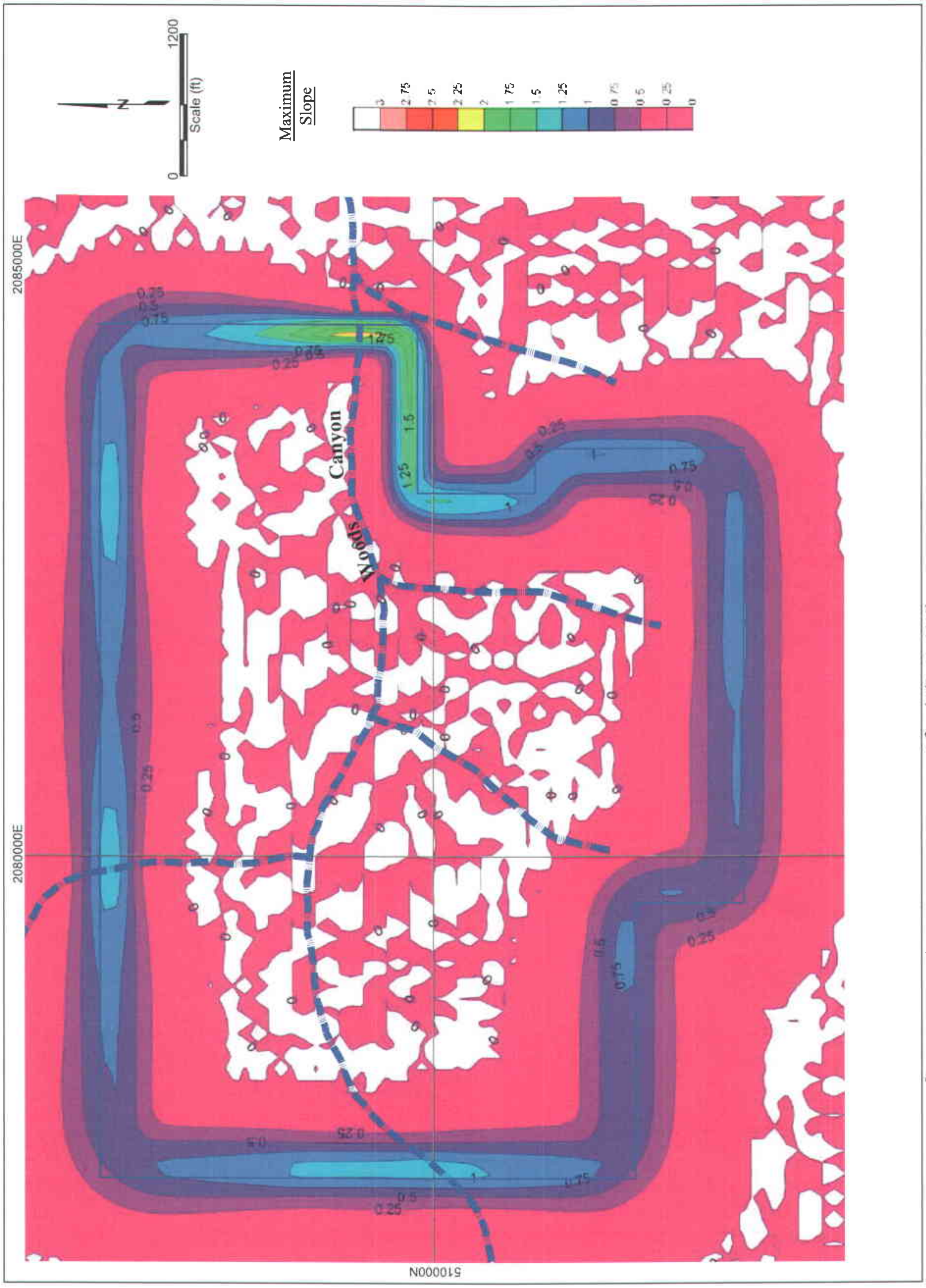


18b. Maximum Horizontal Strain Contours for Case 4a



260-37 Canyon Fuel Skyline [Figure 18(a) - (d)_Model 4a.dwg Layout: Fig 18c]sm/rjl(5-10-2010)

18c. Maximum Curvature Contours for Case 4a



260-37 Canyon Fuel Skyline [Figure 18(a) - (d)_Model 4a.dwg Layout: Fig 18d]sm/rjl(5-10-2010)

Figure 18d. Maximum Slope Contours for Case 4a

eastern edge of the panel 11L (Figure 18b). The horizontal strain levels within the subsidence trough and most importantly, over the gate roads, are close to zero. Maximum curvature contours for Case 4a are presented in Figure 18c and maximum slope contours are presented in Figure 18d, with the eastern boundary of panel 11L specifically exhibiting steep slopes. Similar to the horizontal strain distribution, the maximum curvature and maximum slope distribution within the area of extraction are close to zero.

Comparative plots of predicted subsidence along the Woods Canyon stream axis for Cases 4 and 4a are presented in Figure 19a. In Case 4a, the subsidence along the Woods Canyon stream within the extraction zones is constant at 4.9 ft. A comparison of maximum horizontal strain values between Case 4 and 4a is presented in Figure 19b. This figure indicates that the high tensile strains predicted for the stream segment above the common gate road between panel 11L and 12L in Case 4 has been eliminated in Case 4a, due to yielding of underlying pillars. In Case 4a, the largest values of tensile strains are predicted for the stream as it exits the mining area, which is similar to Case 4. Figures 19c and 19d present comparisons of maximum curvature and maximum slope predicted for the Woods Canyon stream for Case 4 and Case 4a, respectively. The figures indicate an overall reduction in slope and curvature along the stream axis within the extraction area.

AAI believes that yielding of the gate road pillars, as the LAMODEL results indicate, will lessen the impact of subsidence on the Woods Canyon stream in the long term. The stream segment that overlies the gate road shared by panel 11L and 12L may experience transient tensile strains, which are expected to diminish with time.

5.0 Comparison of Results to Western Experience and Surface Water Damage Criteria

An extensive literature review was performed on the effect of subsidence on streams in general, on streams in Utah specifically, and on surface water damage criteria. The potential for communication between the surface and the mine workings was assessed based on the review findings.

A streamflow characterization study of longwall mines in Pennsylvania, West Virginia, and Ohio indicated that streams with 100–150 ft depth of cover did not have visible flow changes (Wade 2008). The study also found that normalized discharge in streams greater than 300 ft above mined panels appeared to recover from impacts of subsidence even at low baseflow, within as early as 15 months after longwall undermining. A study on the effects of longwall mining on streams, wetlands, and riparian areas in southern Washington County, Pennsylvania, indicated that most of the evaluated geomorphic, hydrologic, and biologic indices showed no variation between the mined and unmined segments (Pennsylvania Department of Environmental Protection 2005). However, the study found that the number and dimension of bedforms, such as longer, wider, and deeper pools were observed in the mined segments of streams. Another study investigating the hydrogeologic effects of subsidence at a longwall mine in the Pittsburgh coal seam concluded that stream discharges are decreased for two to three years following subsidence (Carver and Rauch 1994). They also mentioned that streams with longwall undermining, once

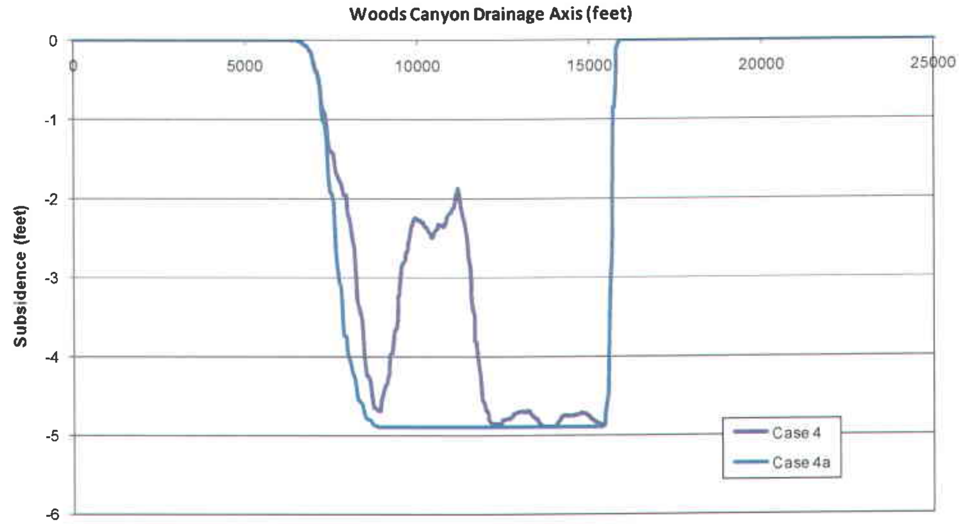


Figure 19a. Comparative Plot of Subsidence along Axis of Woods Canyon, Case 4 and Case 4a

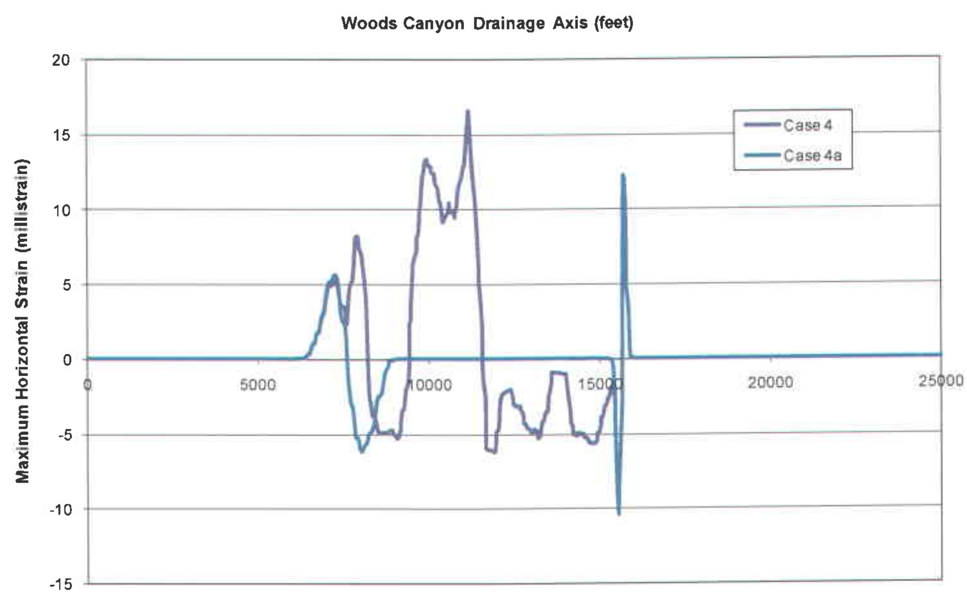


Figure 19b. Comparative Plot of Maximum Horizontal Strain along Axis of Woods Canyon, Case 4 and Case 4a

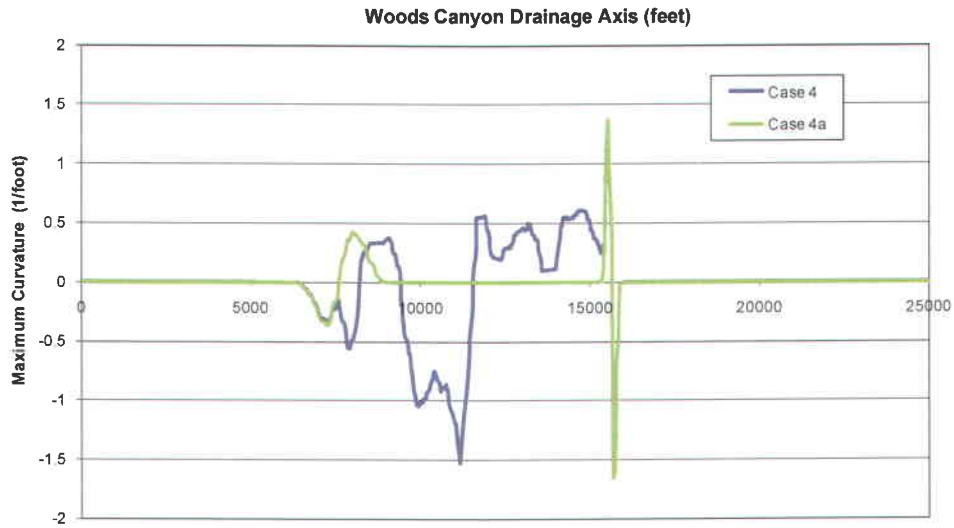


Figure 19c. **Comparative Plot of Maximum Curvature along Axis of Woods Canyon, Case 4 and Case 4a**

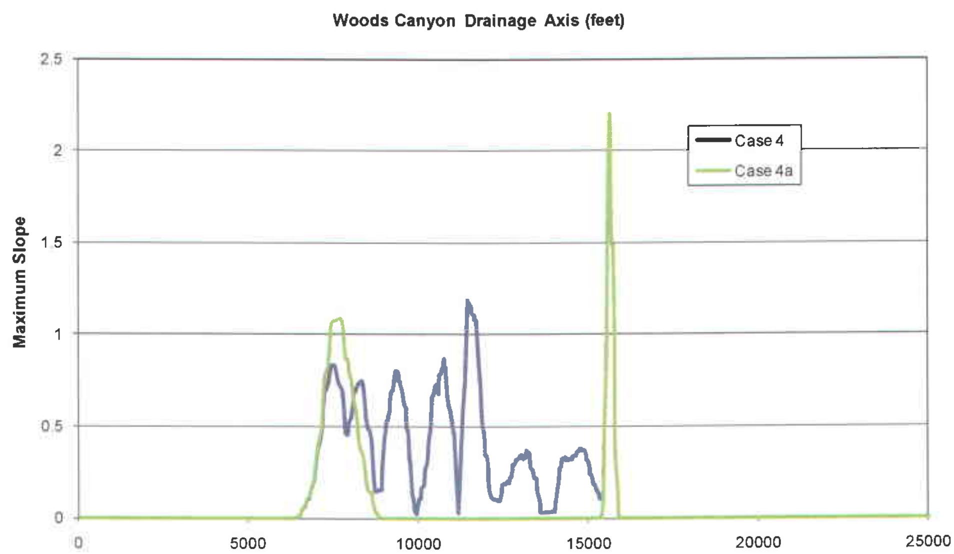


Figure 19d. **Comparative Plot of Maximum Slope along axis of Woods Canyon, Case 4 and Case 4a**

recovered, have lower high baseflow and higher low baseflow, essentially meaning more uniform stream discharge. A hydrogeologic analysis of streamflow in relation to underground mining was performed in northern West Virginia (Gill 2000). The study reported that stream segments between two adjacent longwall panels often experienced dewatering effects from overlapping tensional strain areas. Another conclusion of the study was that thick sediment presence (more than 10 inches), with 60% or greater medium-grained (small pebbles to small cobbles) particles with some fine sediment (sand and finer particles), leads to less water loss due to subsidence.

Utah Division of Oil, Gas and Mining (DOGM) regulations require that any impact to water rights on a perennial stream need to be mitigated with an alternate water supply. Literature review and AAI's communication with the Bureau of Land Management (BLM) indicates that sixty times the extraction thickness is regarded as the acceptable approach for determining cover depth for undermining a stream.

Review of the study assessing changes in stream channel characteristics and hydraulic parameters at Burnout Canyon indicated that the changes in channel characteristics were subtle with the only conspicuous changes being increase in the length of cascades and some increase in pool volumes. At this site, subsidence had no discernible effect on baseflows or near-channel landslides (Forestry Sciences Laboratory 1998). No mitigation was required or implemented at this site.

The United States Geological Survey (USGS) reported that longwall mining under Miller Creek, a perennial stream in Carbon and Emery Counties, Utah, with approximately 600 ft of cover depth, produced dried segments at low flows (USGS 2007). However, the length of dried segments decreased from 1,600 ft to 300 ft during the two years of observations. The report also quotes a communication with BLM to the effect that longwall mining leases generally require a cover depth of 500 ft below a perennial stream.

A study on subsidence-induced cracks in Utah reported that such tension cracks experienced gradual closure, once tensile stresses are reduced or relaxed (Degraff 1981). The mean closure rate was 0.12 inches/week, with individual crack closures rates from 0.08 to 0.4 inches/week.

The typically recommended horizontal strain damage criterion for surface water bodies is 5 millistrain (Wardell 1976).

Finally, AAI found instances where leases had been granted for longwall mining under perennial and intermittent streams, with monitoring and mitigation plans in place. These cases were for Box Canyon over the SUFCO mine and the Crandall stream at the Crandall Canyon mine.

AAI also performed a review of surface water damage criteria and its evolution over the years. The United States Bureau of Mines (USBM 1979) categorized perennial streams such as Woods Canyon as water bodies with the potential for major subsidence impacts (as opposed to large rivers and lakes, which were classified as catastrophic water bodies). The cover depth criteria for major potential water bodies given by the USBM requires the overburden rocks to be classified into one of four rock types: (I) minimum cumulative 20 feet clay, (II) minimum

75% shale, (III) shaley and silty sandstone, and (IV) 100% limestones and sandstones. Once the overburden has been classified appropriately, a multiplier is applied to the extraction thickness to arrive at the safe cover depth. A reproduction of the original table for cover depth determination is included in the Appendix. Since the overburden at Woods Canyon may be classified as class III, the appropriate minimum cover depth for 10 ft of extraction thickness is 461 ft. Most of the later references on the topic of appropriate cover depth (the Mining Engineering Handbook [Hartman 1992] and [Maleki 2008]) tend to apply a generic cover depth criterion of sixty times the extraction thickness. In the original report (USBM 1979), this criterion was meant to be applied only to extraction below water bodies of catastrophic potential size. Therefore, it appears that the often-quoted factor of 60 times the extraction thickness is a conservative generalization that somewhat mischaracterizes the USBM study recommendations.

6.0 Conclusions and Recommendations

Given the findings of the literature review and the results of the subsidence prediction analysis, AAI believes that a minimum cover depth of 475 ft is likely to be adequate for safe undermining of the Woods Canyon stream. Although the recommended horizontal strain value of 5 millistrain is predicted to be exceeded along certain segments of the Woods Canyon stream, the stream gradient is steep enough to accommodate such strains. Also, Burnout Canyon and James Canyon streams were predicted to have undergone similar or higher magnitude strains, and were successfully undermined without the need for restoration. Finally, research of subsidence impacts on streamflow across the coalfields in the United States, and Utah in particular, indicate that although perennial stream and channel characteristics are likely to be affected over the first two to three years following longwall mining, such streams are likely to recover soon afterwards in the presence of sufficient cover depth.

In summary:

- The predicted subsidence index values for longwall mining under the Woods Canyon, such as subsidence, maximum horizontal strain, curvature, and slope, are less than or similar to corresponding calibrated values in Burnout and James Canyon. Since both Burnout and James Canyon streamflows were unaffected, AAI believes that the Woods Canyon stream is likely to respond in a similar manner.

- If panel 11L is extended past the current planned stop line under 600 ft of cover, AAI does not recommend extending it to less than 475 ft of cover. While extending the panel from the 600-ft stop line to a 475-ft stop line engenders more subsidence risk to the drainage, according to the original USBM (1979) criteria for mining under major potential surface water bodies, this should provide adequate depth of cover against the disruption of the Woods Canyon stream. Using this criterion, other panels in the district could be mined to the eastern limit of the reserve, as long as they do not undermine a drainage with less than 475 ft of cover.

- The predicted maximum horizontal tensile strain values for segments of the Woods Canyon stream near the 11L/12L boundary are higher than the recommended damage threshold. However, in AAI's opinion the steep gradient of the stream will tend to accommodate such strains without excessive pool and cascade formation. Also, yielding of the gate road pillars is expected to lessen the strain values over time. If feasible, shifting the mining layout so that large portions of the stream are not in the inter-panel transient tension zones created during longwall mining would tend to mitigate subsidence effects on the stream.

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APPENDIX

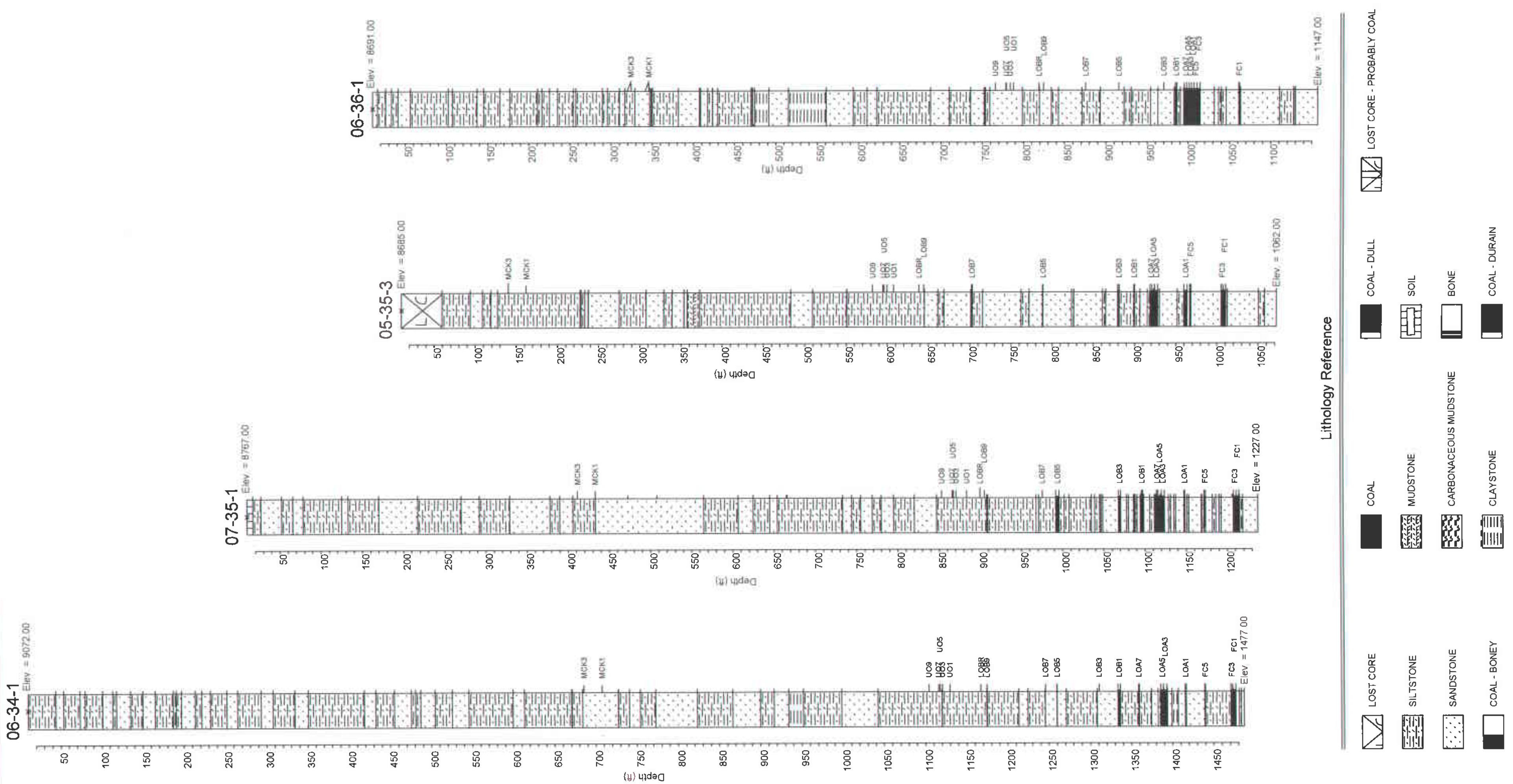

Figure A-1. Lithologic Logs from Selected Boreholes in the Woods Canyon Area

AGAPITO ASSOCIATES, INC.
Mining and Civil Engineers and Geologists

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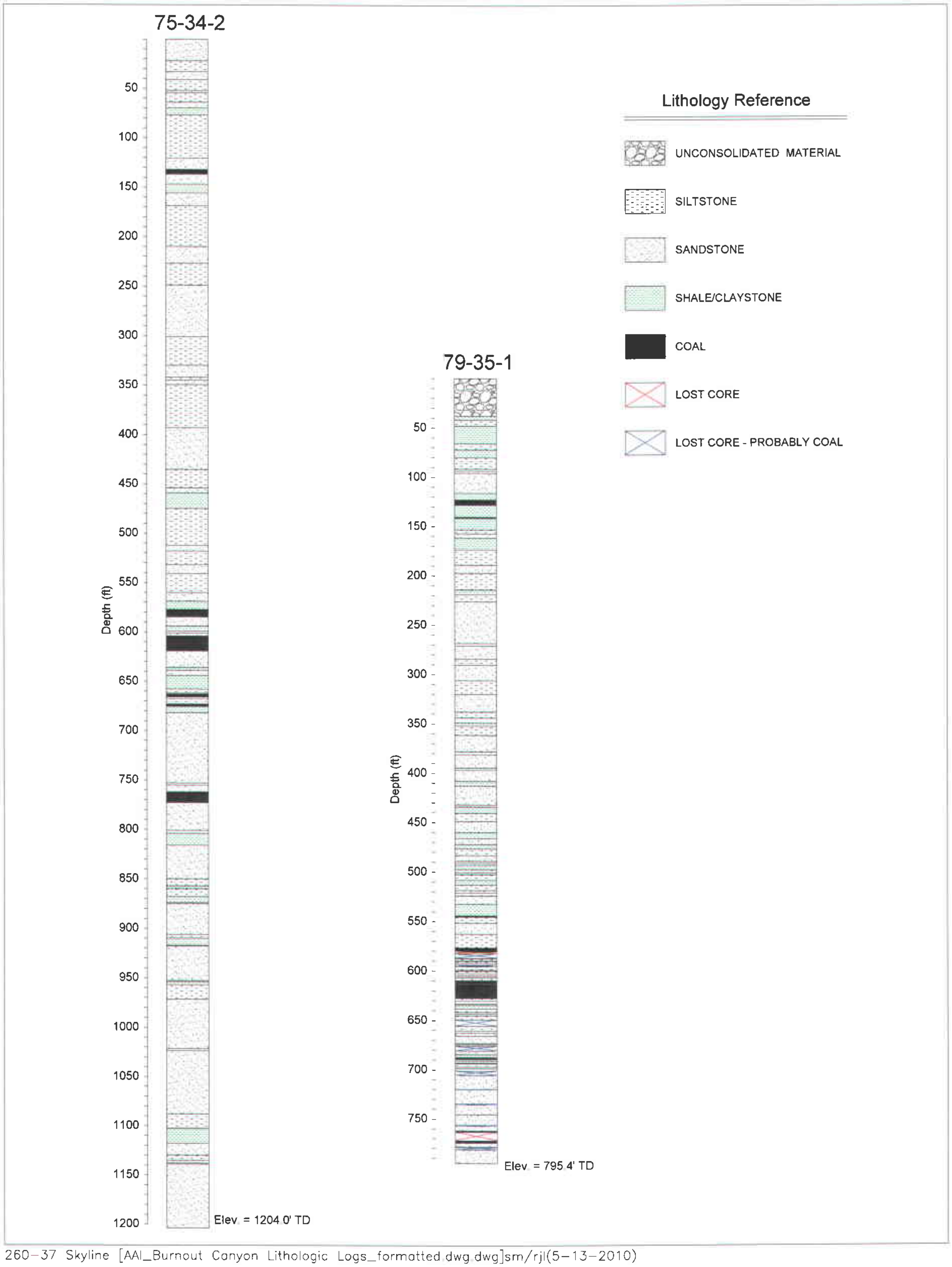

Figure A-2. Lithologic Logs from Selected Boreholes in the Burnout Canyon Area

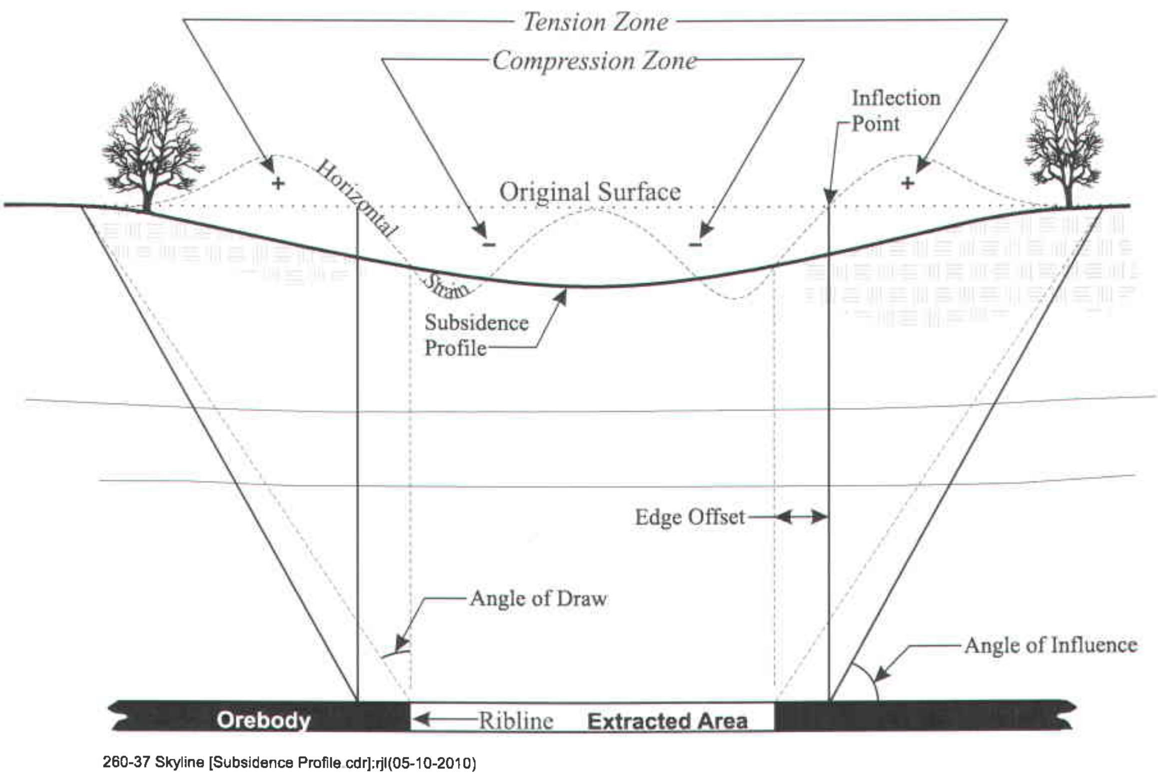

Figure A-3. Schematic Diagram of Subsidence Parameters

Table A-1. Recommended Minimum Cover Depth for Mining Under Water Bodies of Major Importance

Seam Thickness	(a) Height of Disturbed Strata Above Seam		(b) Aquiclude Zone Thickness								(c) Depth of Surface Cracks		Total Recommended Cover Depth*							
			I**		II		III		IV				I		II		III		IV	
			Minimum 20' Clay		Minimum 75% Shale		Shaley & Silty Sandstones		100% Limestones and Sandstones											
ft	ft	t***	ft	t	ft	t	ft	t	ft	t	ft	t	ft	t	ft	t	ft	t	ft	t
3	174	58	30	10	50	17	90	30			50	17	254	85	274	92	314	105		
4	203	51	30	8	50	13	90	23			50	13	283	72	303	77	343	87		
5	226	45	30	6	50	10	90	18			50	10	316	61	326	65	366	73		
6	249	42	30	5	50	8	90	15			50	8	329	55	349	59	389	65		
7	269	38	30	4	50	7	90	13	Special Investigations Required		50	7	349	49	369	52	409	58	Special Investigations Required	
8	285	36	30	4	50	6	90	11			50	6	365	46	385	49	425	53		
9	305	34	30	3	50	6	90	10			50	6	385	43	405	45	445	50		
10	321	32	30	3	50	5	90	9			50	5	401	40	421	42	461	46		
11	352	32	30	3	50	5	90	8			50	5	432	39	452	41	492	45		
12	360	30	30	3	50	4	90	8			50	4	440	37	460	38	500	42		

* Total recommended cover depth = (a)+(b)+(c)

**I, II, III & IV are overburden rock types

*** t = seam thickness multiplier

(yellow) is analyzed case for Woods Canyon drainage